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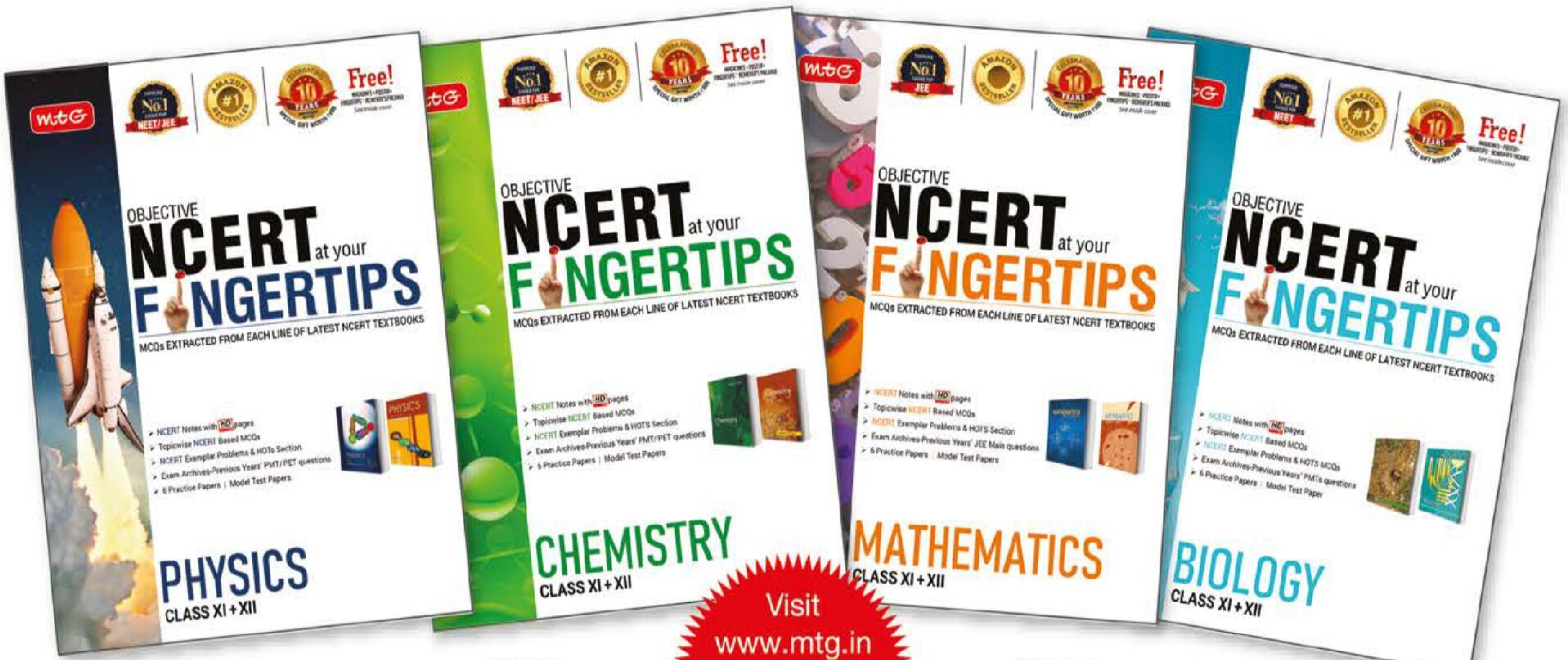

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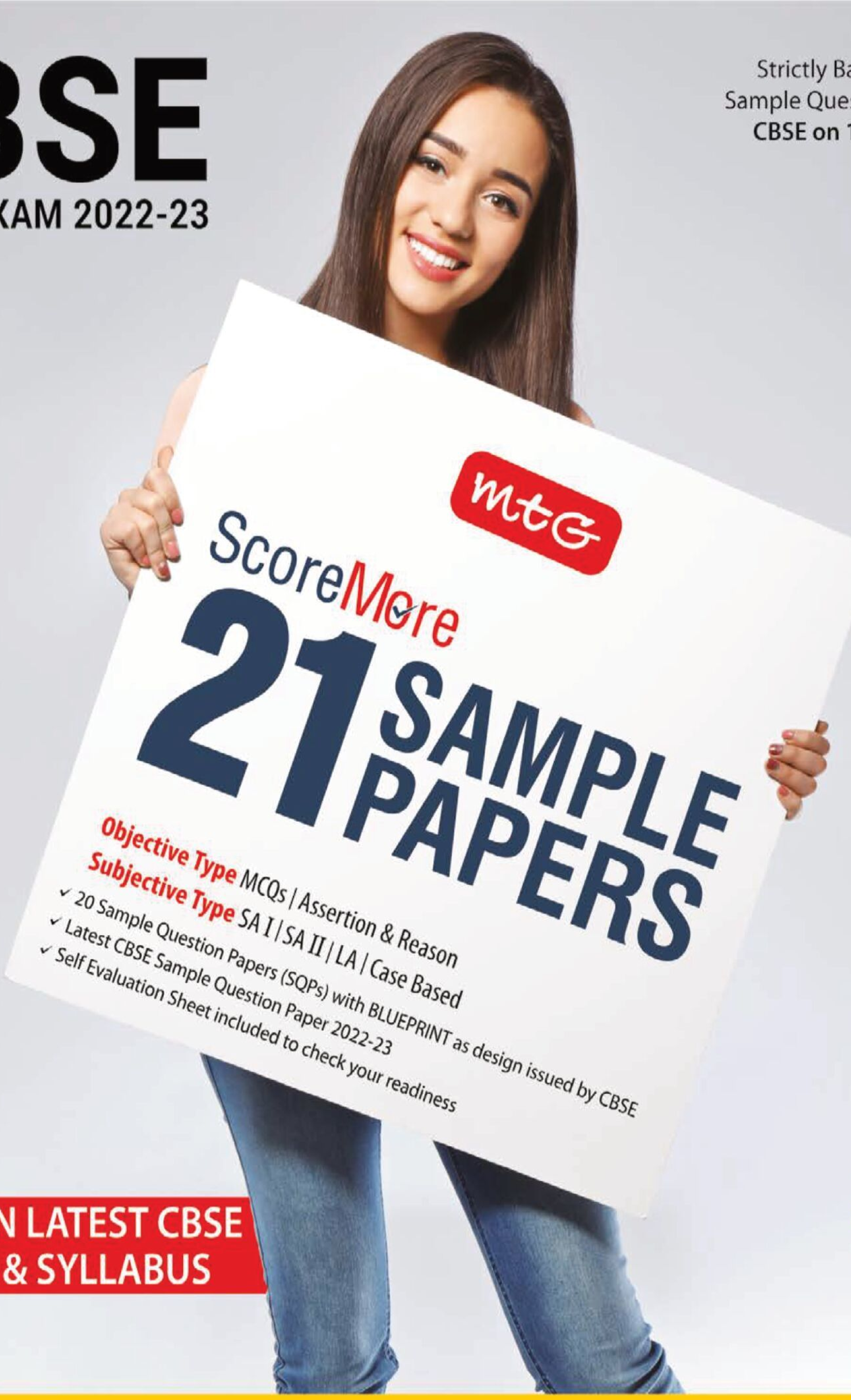
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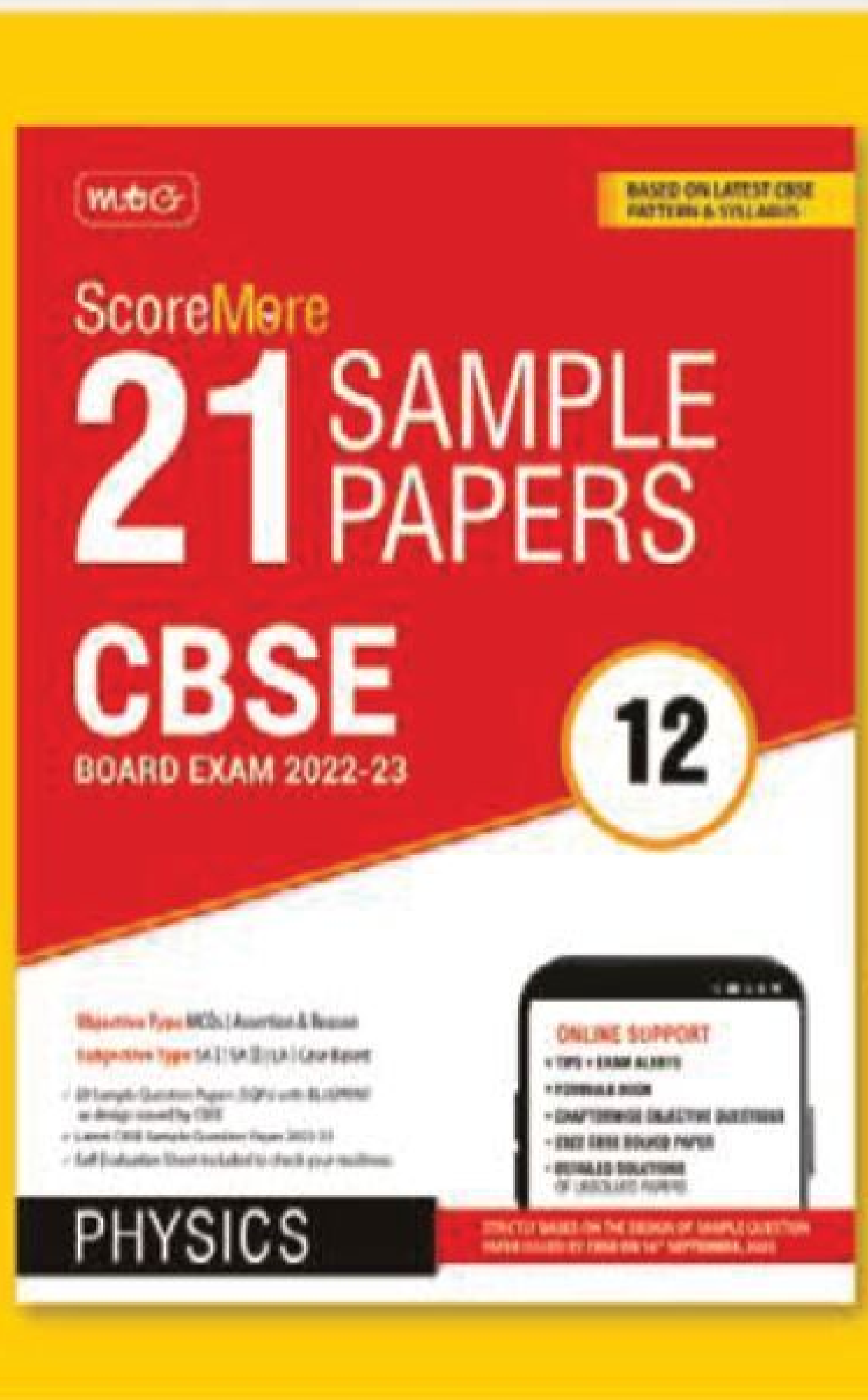
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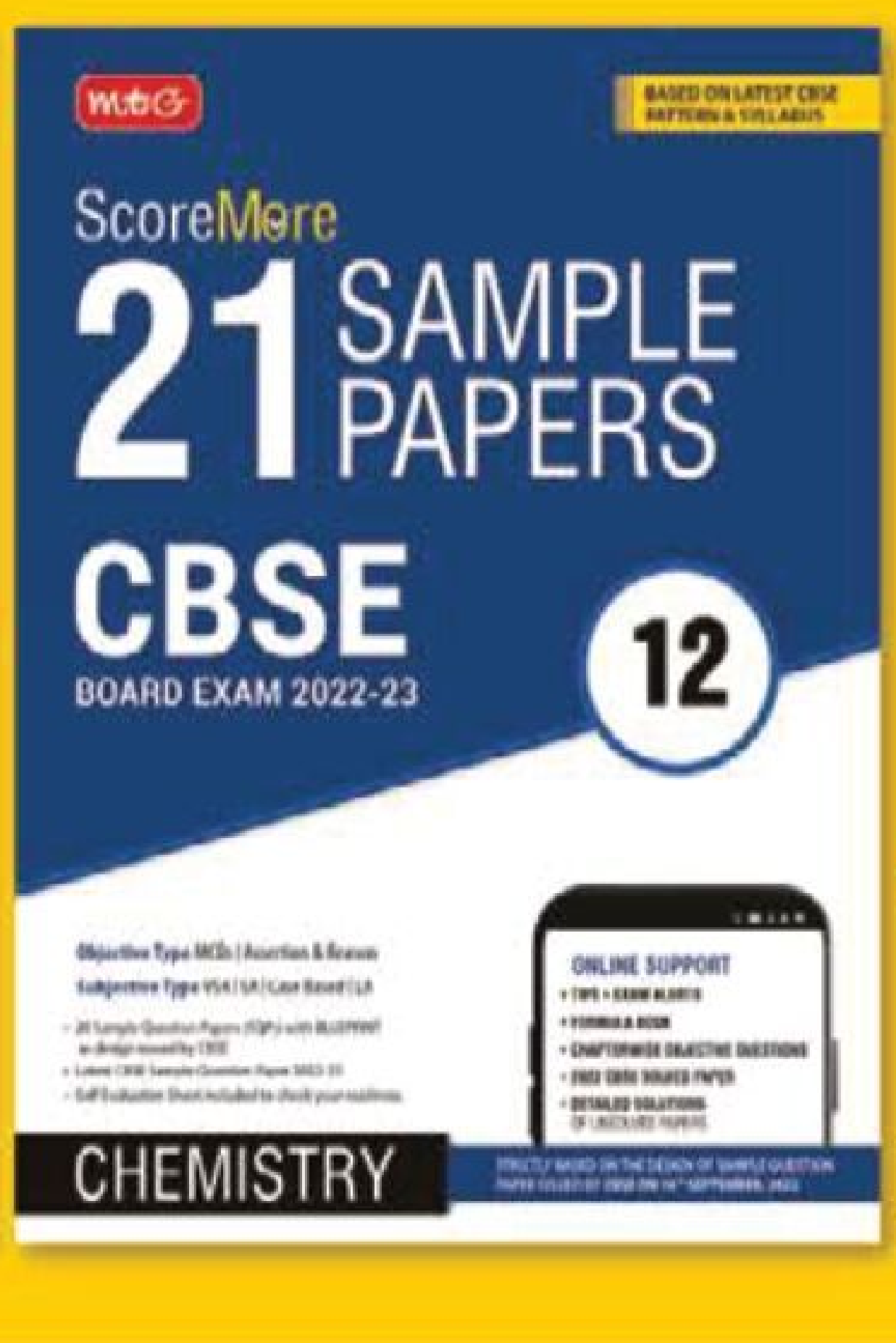
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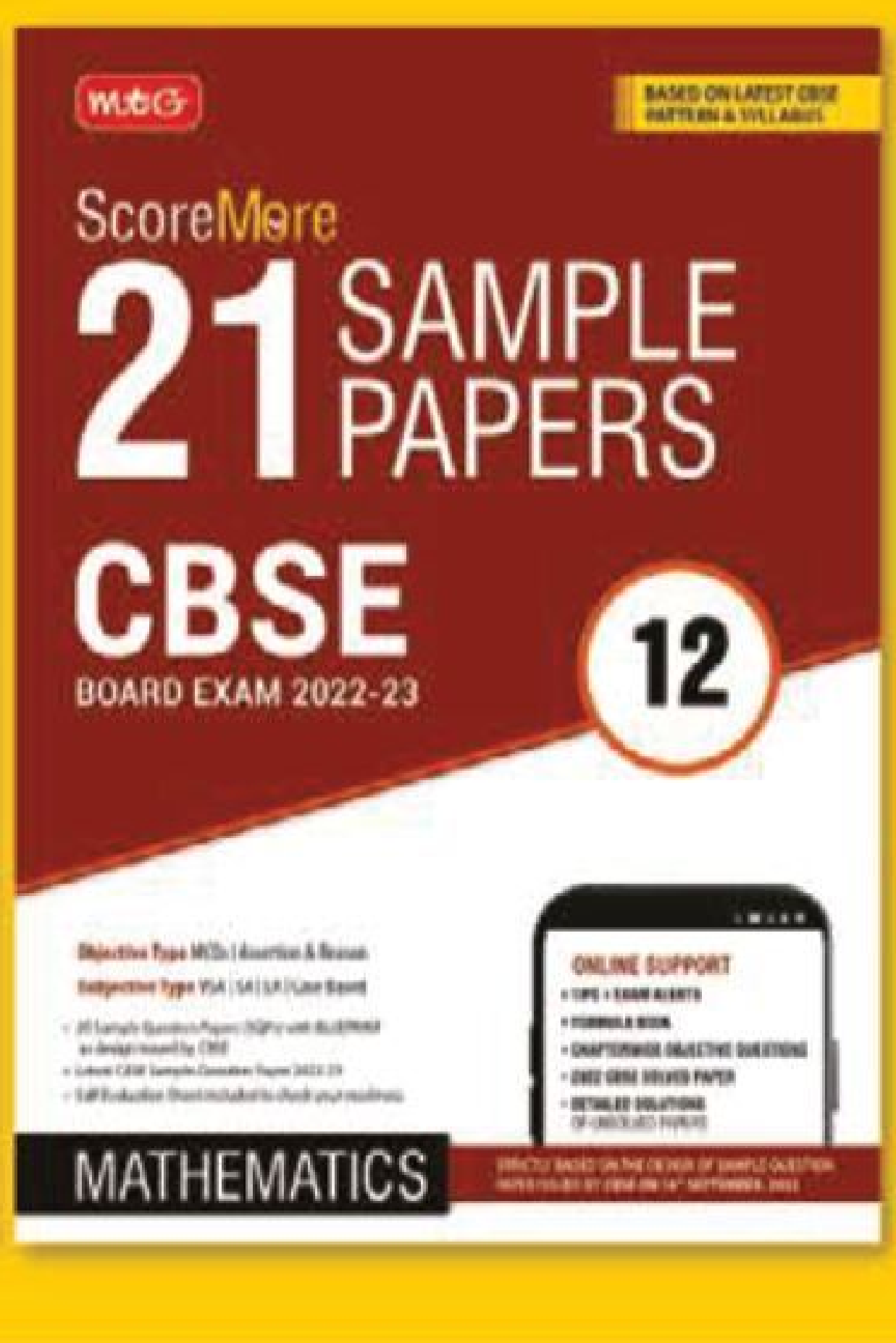
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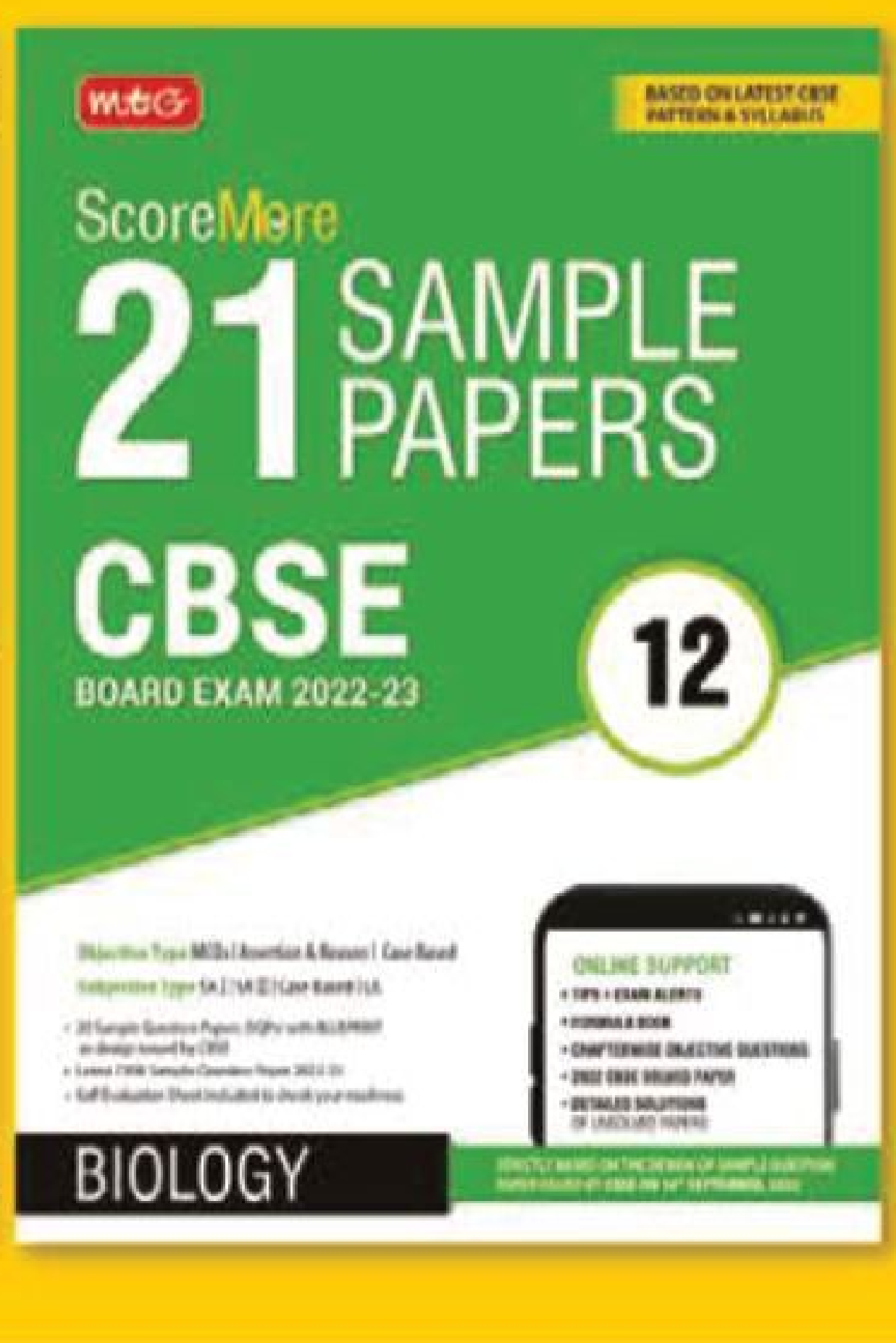
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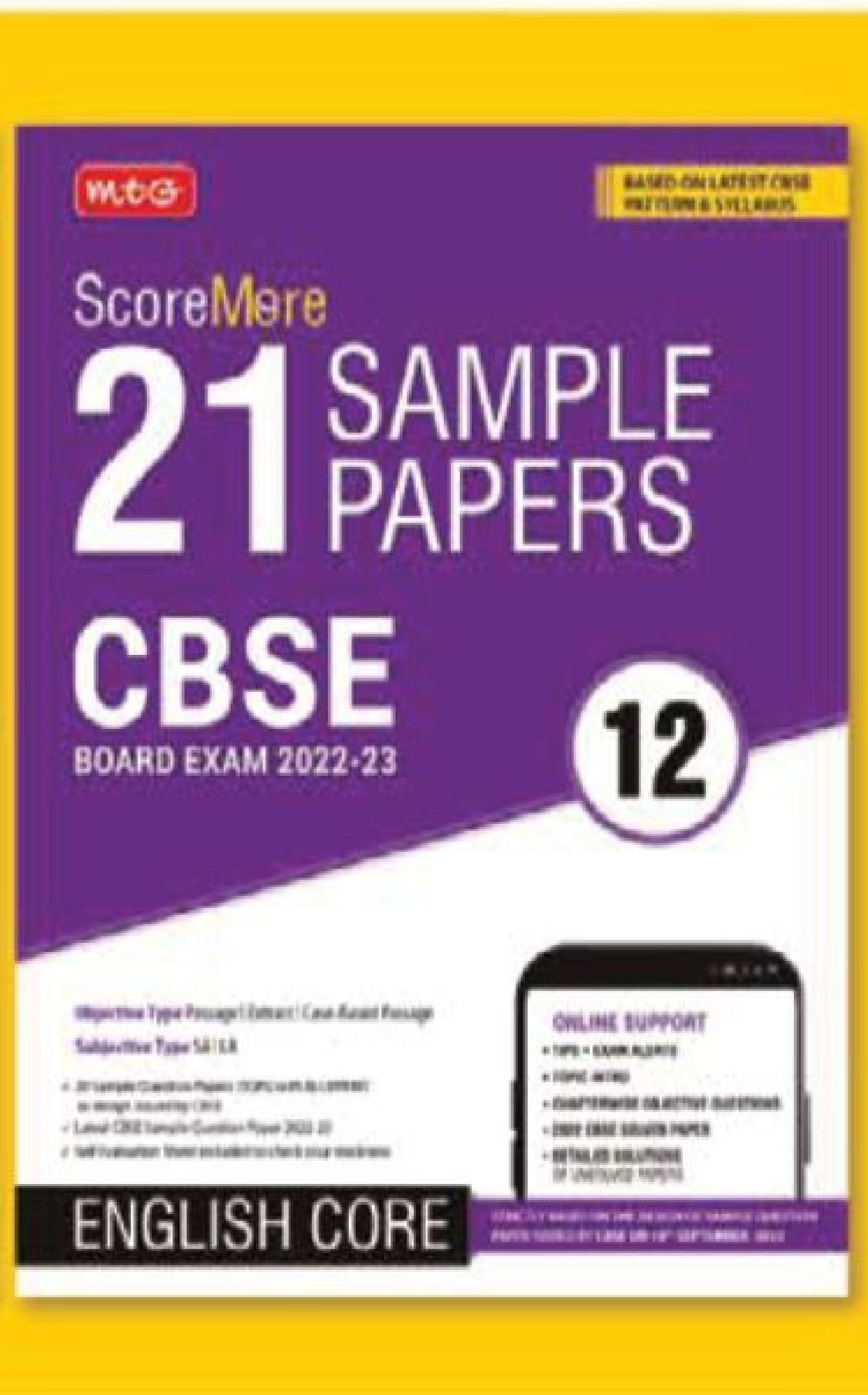
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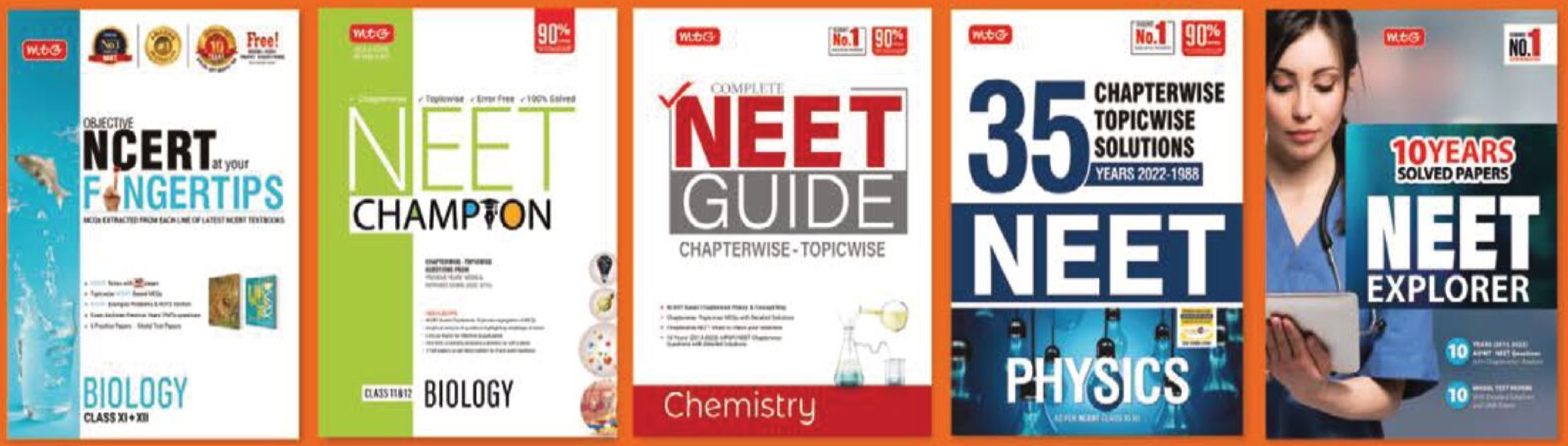
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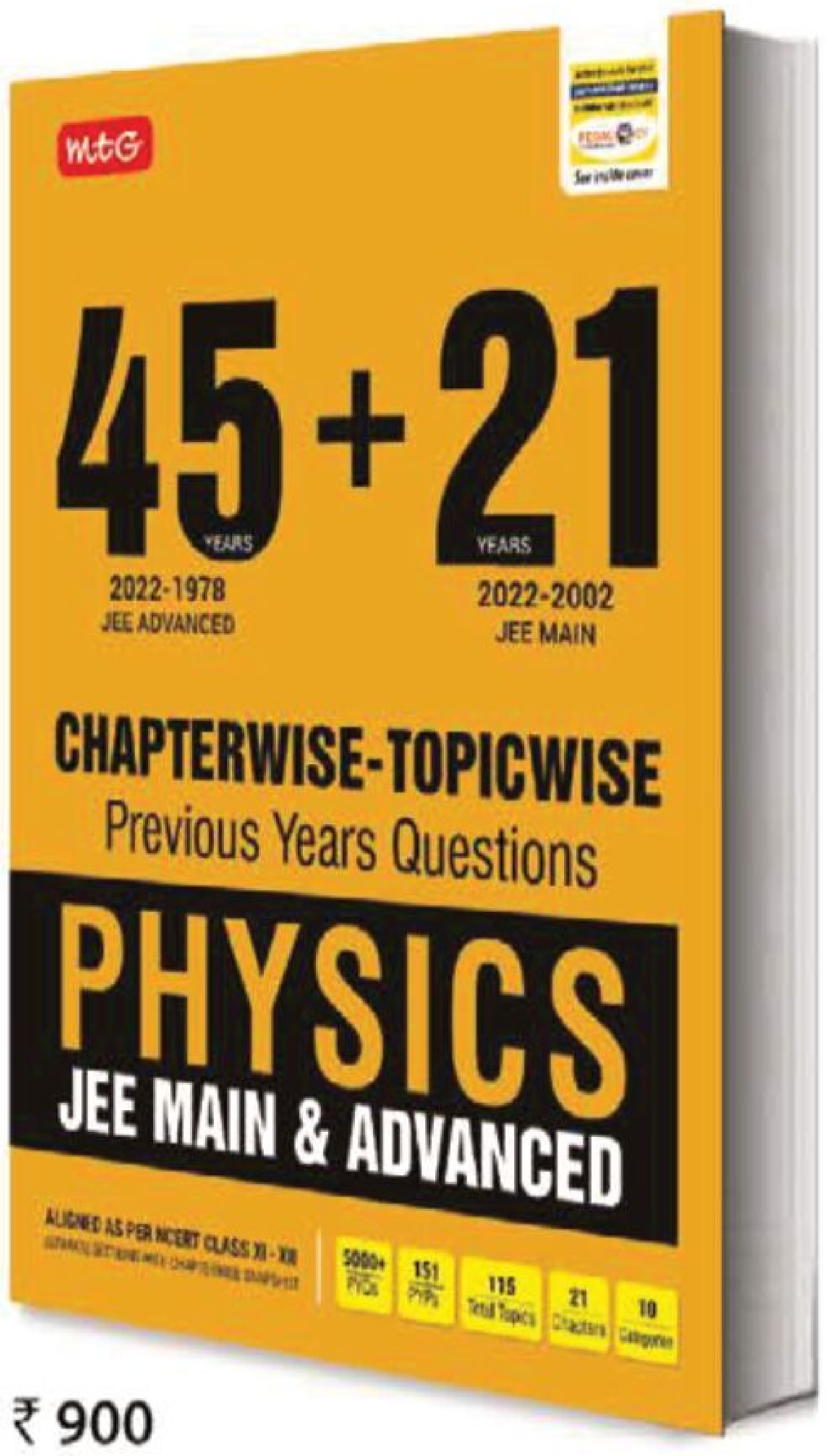
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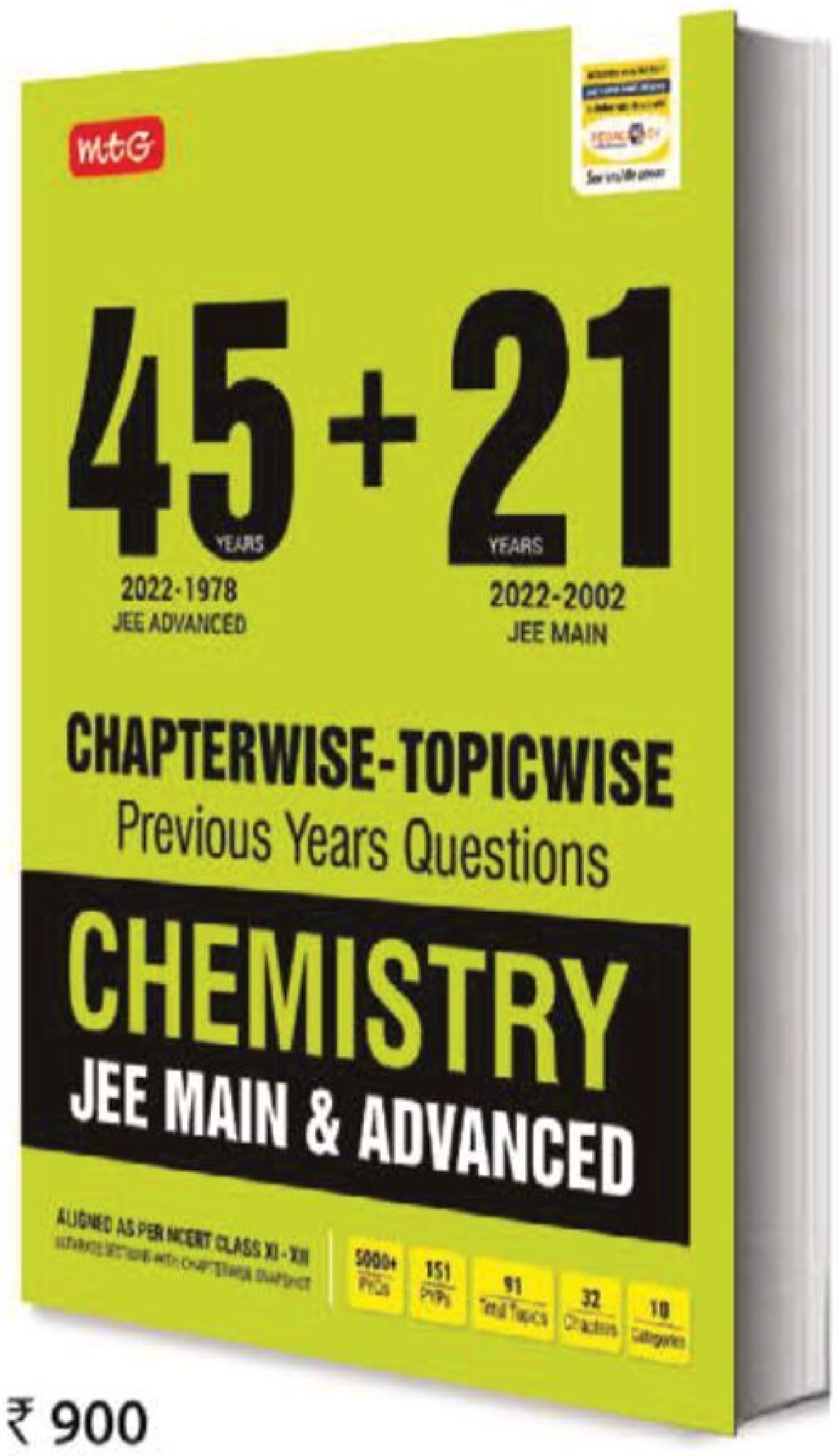
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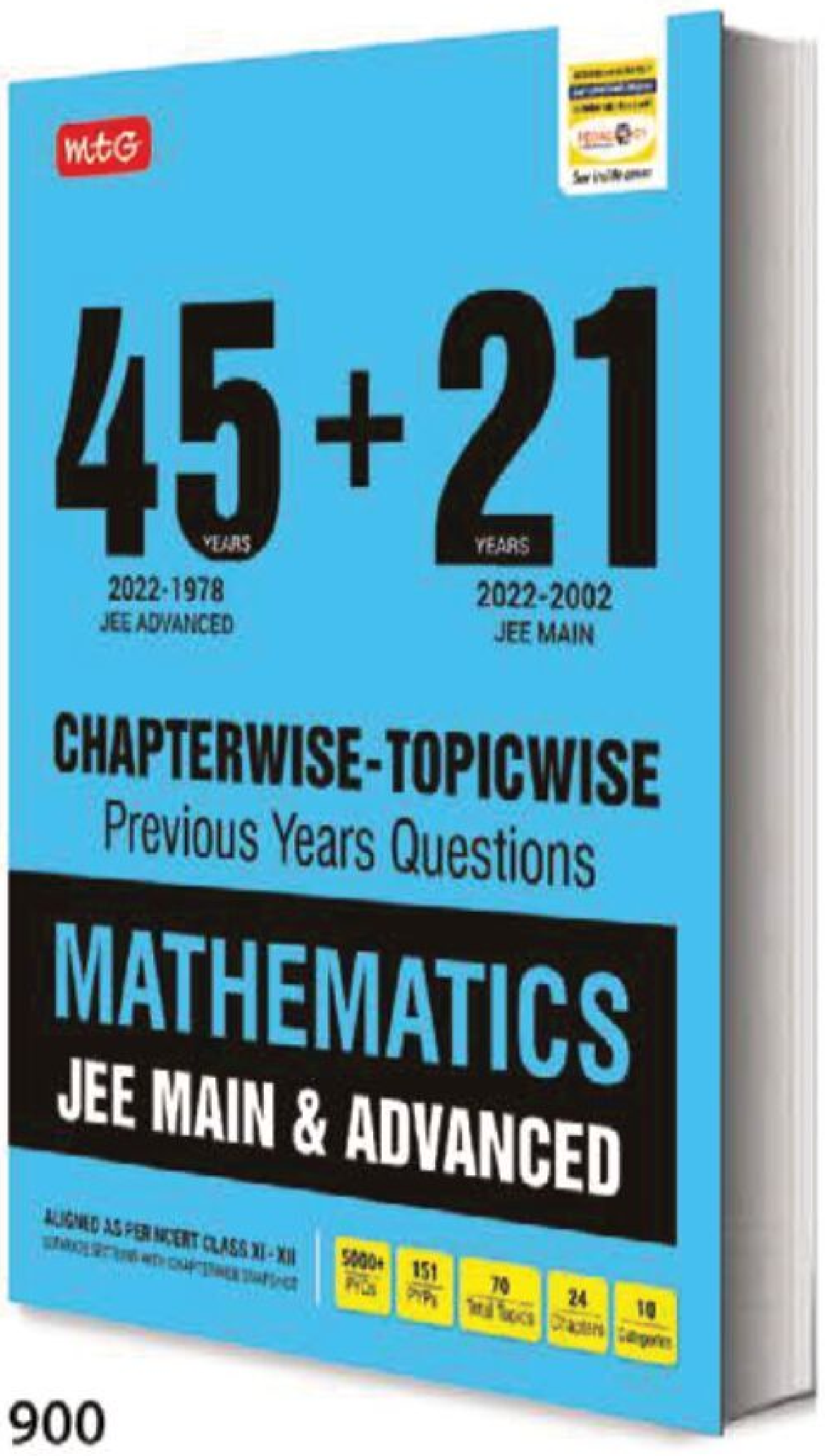
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VOLUME 32 No. 1 January 2023

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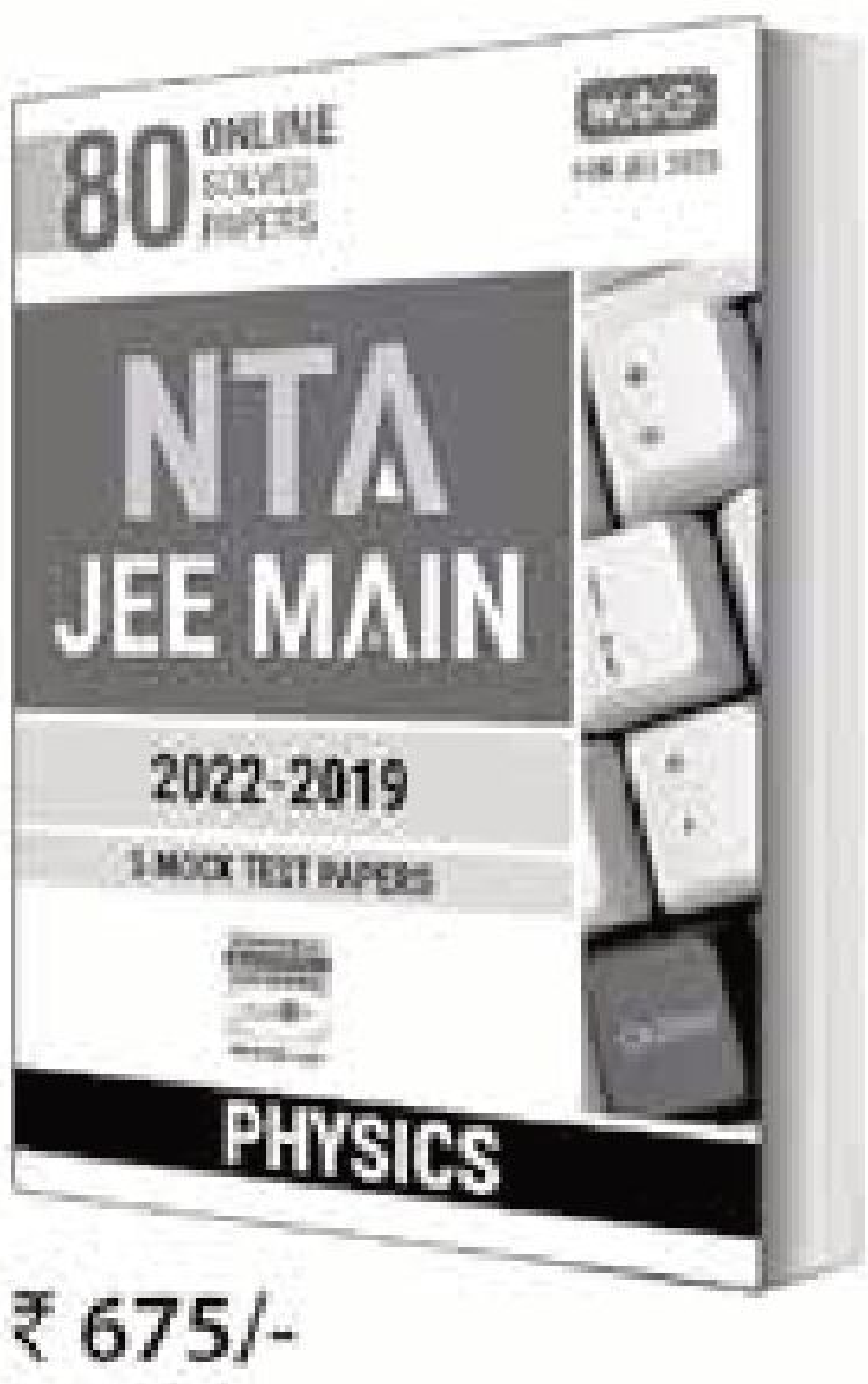
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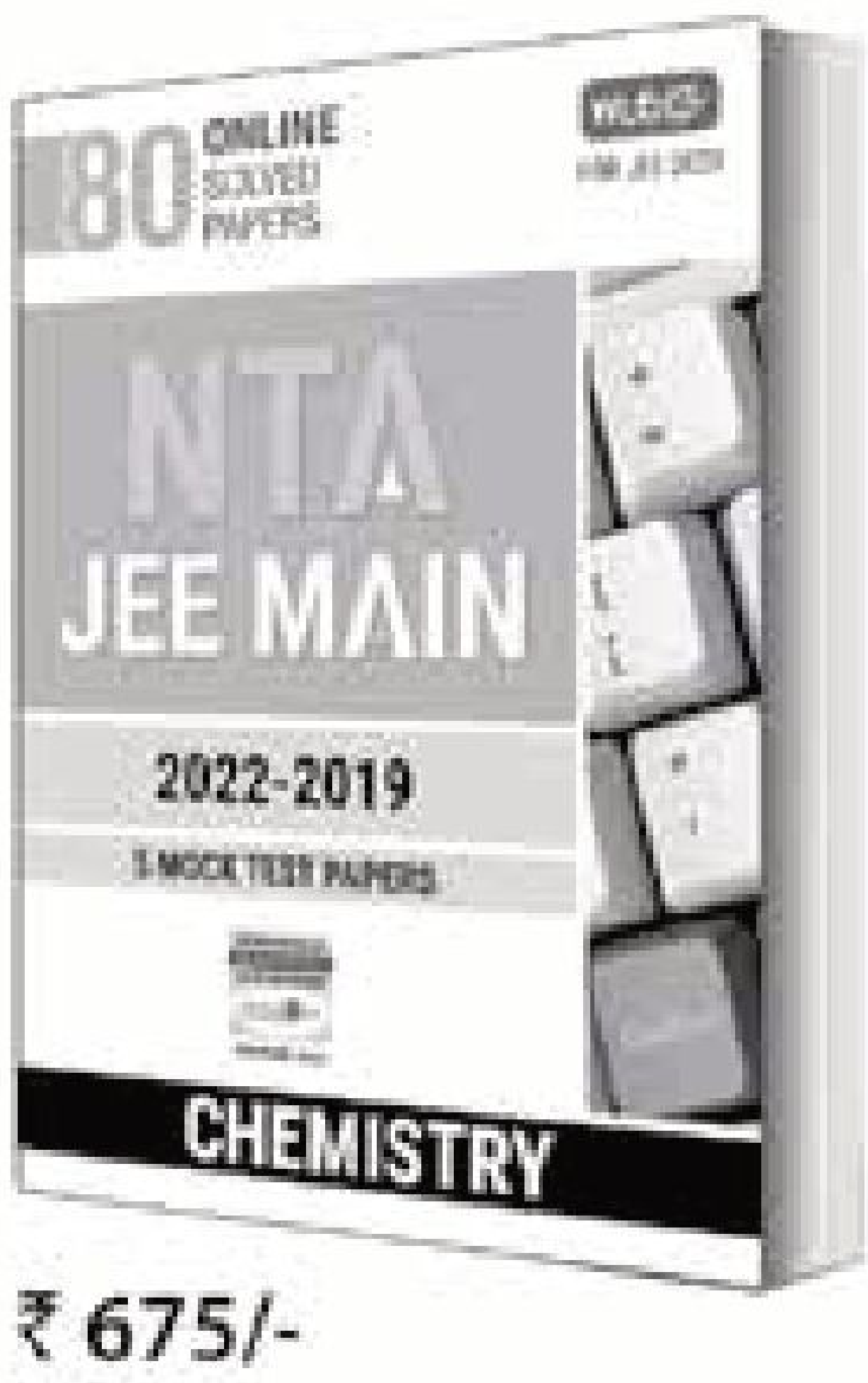
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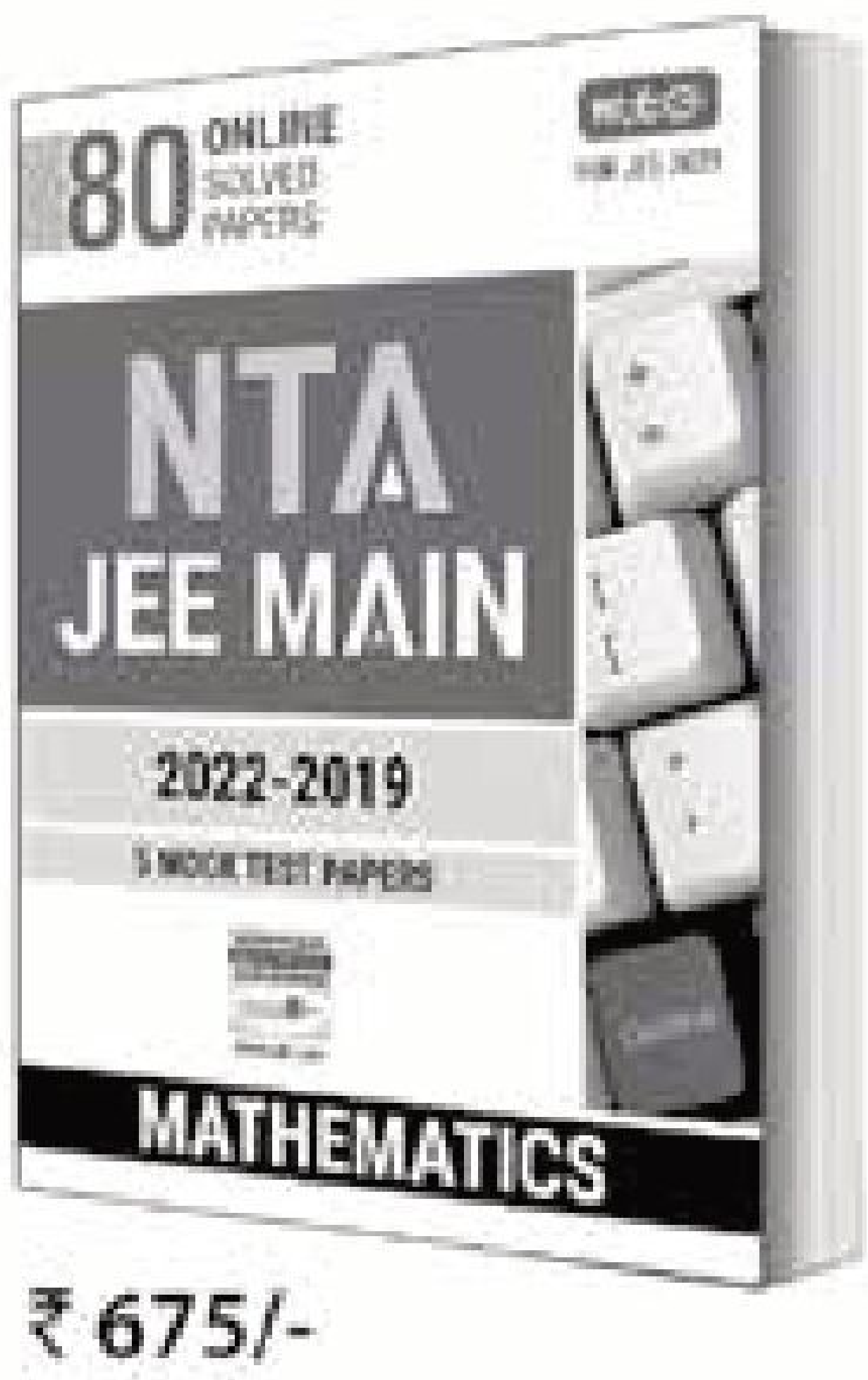
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SECTION-A (MULTIPLE CHOICE QUESTIONS)

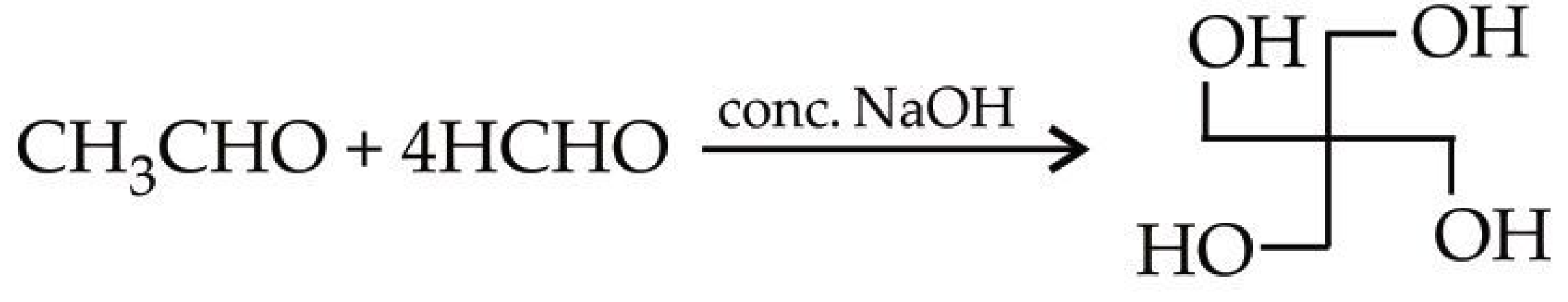
1. What are the functional groups present in the structure of maltose?
   (a) One acetal and one ketal
   (b) One ketal and one hemiketal
   (c) One acetal and one hemiacetal
   (d) Two acetals

2. CsCl crystallises in body-centred cubic lattice. If a is its edge length then which of the following expressions is correct?
   (a) $r_{Cs^+} + r_{Cl^-} = \sqrt{3}a$ (b) $r_{Cs^+} + r_{Cl^-} = 3a$
   (c) $r_{Cs^+} + r_{Cl^-} = \frac{3a}{2}$ (d) $r_{Cs^+} + r_{Cl^-} = \frac{\sqrt{3}}{2}a$

3. Food preservatives prevent spoilage of food due to microbial growth. The most commonly used preservative(s) is/are
   (a) table salt, sugar
   (b) vegetable oils and sodium benzoate
   (c) C_6H_5COONa
   (d) All of these

4. Which of the following statements is not true about classical smog?
   (a) It contains compounds of reducing nature.
   (b) It is produced in cold and humid climate.
   (c) Its main components are produced by the action of sunlight on emissions of automobiles and factories.
   (d) It contains smoke, fog and SO_2.

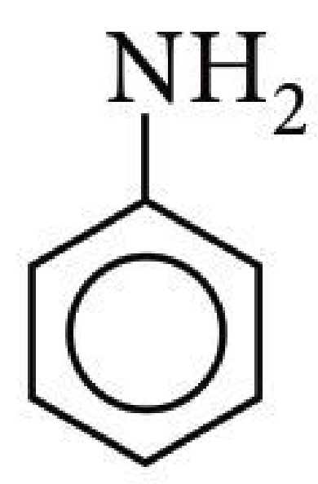
5. The number of aldol reaction(s) that occurs in the given transformation is

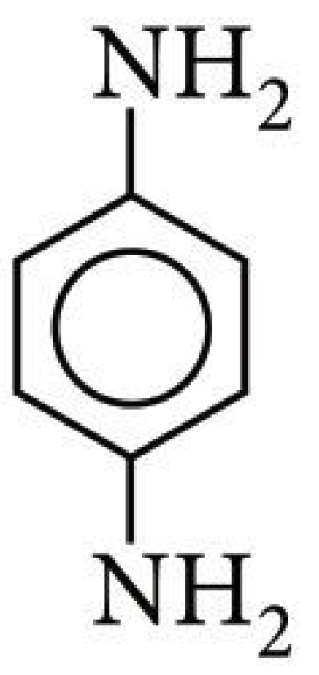


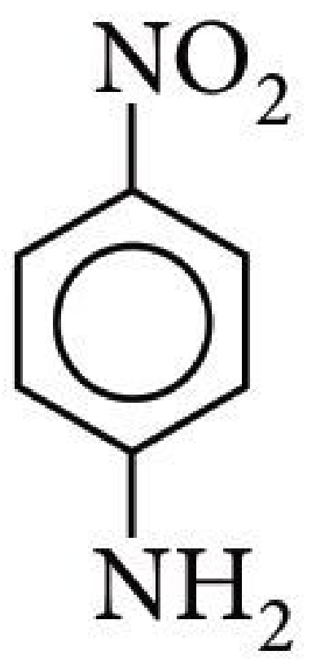
   (a) 1 (b) 2 (c) 3 (d) 4

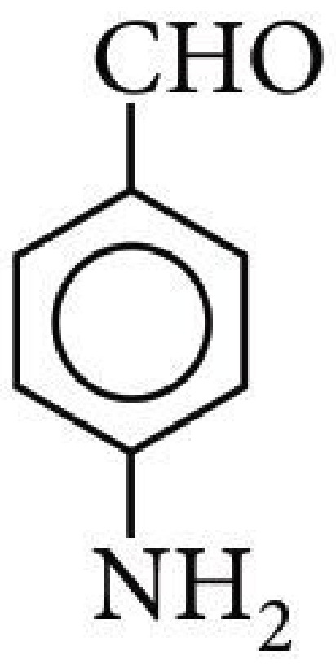
6. Biuret test is not given by
   (a) proteins (b) carbohydrates
   (c) polypeptide (d) urea.

7. Amongst the following, the most basic compound is

(a) 

(b) 

(c) 

(d) 

8. The compound formed upon combustion of potassium metal in excess air is
   (a) K_2O_2 (b) KO_2 (c) K_2O (d) KOH

9. The number of donor sites in dimethyl glyoxime, glycinato, diethylene triamine and EDTA are respectively
   (a) 2, 2, 3 and 4 (b) 2, 2, 3 and 6
   (c) 2, 2, 2 and 6 (d) 2, 3, 3 and 6

10. The hybridisation and oxidation state of two oxygen atoms in H_2O_2 are respectively
   (a) $sp^2, -1$ (b) $sp^2, +1$ (c) $sp^3, -1$ (d) $sp^3, +1$

11. Match the catalysts given in column-I with the correct processes given in column-II and select the correct option.

	Column-I (Catalyst)		Column-II (Process)
(A)	$TiCl_4$	(i)	Wacker process
(B)	$PdCl_2$	(ii)	Ziegler–Natta polymerization
(C)	$CuCl_2$	(iii)	Contact process
(D)	V_2O_5	(iv)	Deacon's process

   (a) (A) - (ii), (B) - (iii), (C) - (iv), (D) - (i)
   (b) (A) - (iii), (B) - (i), (C) - (ii), (D) - (iv)
   (c) (A) - (iii), (B) - (ii), (C) - (iv), (D) - (i)
   (d) (A) - (ii), (B) - (i), (C) - (iv), (D) - (iii)

12. Oxidation state of nitrogen is correctly given for

	Compound	Oxidation state
(a)	$[Co(NH_3)_5Cl]Cl_2$	0
(b)	NH_2OH	+1
(c)	$(N_2H_5)_2SO_4$	+2
(d)	Mg_3N_2	−3

13. In the solid state, PCl_5 exists as
(a) $[PCl_4]^-$ and $[PCl_7]^+$ ions
(b) Covalent PCl_5 molecule
(c) $[PCl_4]^+$ and $[PCl_6]^-$ ions
(d) $[PCl_3]^{2-}$ and $[PCl_5]^{2+}$ ions.

14. For the reaction, $CO + \frac{1}{2}O_2 \rightleftharpoons CO_2$. The correct relation between K_p and K_c is
(a) $K_p = K_c$ (b) $K_p = K_cRT$
(c) $K_p = K_c(RT)^{1/2}$ (d) $K_p = K_c(RT)^{-1/2}$

15. Which one of the following is not a method of concentration of metal ores?
(a) Gravity separation
(b) Froth floatation process
(c) Electromagnetic separation
(d) Smelting

16. 1.0 litre of N_2 and 7/8 litre of O_2 at the same temperature and pressure were mixed together. What is the relation between the masses of the two gases in the mixture?
(a) $m_{N_2} = 3m_{O_2}$ (b) $m_{N_2} = 8m_{O_2}$
(c) $m_{N_2} = m_{O_2}$ (d) $m_{N_2} = 16m_{O_2}$

17. Which one of the following characteristics is not correct for physical adsorption?
(a) Adsorption on solids is reversible.
(b) Adsorption increases with increase in temperature.
(c) Adsorption is spontaneous.
(d) Both enthalpy and entropy of adsorption are negative.

18. Outermost electronic configuration of a group 13 element, E is $4s^2\,4p^1$. The electronic configuration of an element of p-block period-five placed diagonally to element, E is
(a) $[Xe]\,5d^{10}\,6s^2\,6p^2$ (b) $[Ar]3d^{10}\,4s^2\,4p^2$
(c) $[Kr]\,3d^{10}\,4s^2\,4p^2$ (d) $[Kr]\,4d^{10}\,5s^2\,5p^2$

19. Which one of the following is wrong about molecularity of a reaction?
(a) It may be whole number or fractional.
(b) It is calculated from reaction mechanism.
(c) It is the number of molecules of the reactants taking part in a single step chemical reaction.
(d) It is always equal to the order of elementary reaction.

20. The number of atoms present in one mole of an element is equal to Avogadro number. Which of the following elements contains the greatest number of atoms?
(a) 4 g He (b) 46 g Na
(c) 0.40 g Ca (d) 12 g He

SECTION-B (NUMERICAL TYPE QUESTIONS)

Attempt any 5 questions out of 10.

21. An acidic solution of dichromate is electrolyzed for 8 minutes using 2A current. As per the following equation, $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$
The amount of Cr^{3+} obtained was 0.104 g. The efficiency of the process(in %) is ________.
(Take : F = 96000 C, At. mass of chromium = 52)

PUBLIC NOTICE

NTA Examination Calendar for Academic Year 2023-24

The Ministry of Education (MoE), Government of India (GoI) has established the National Testing Agency (NTA) as an independent, autonomous, and self-sustained premier testing organization under the Societies Registration Act (1860) for conducting efficient, transparent, and international standardized tests in order to assess the competency of candidates for admission to premier higher education institutions with a mission to improve equity and quality in education by developing and administering research-based valid, reliable, efficient, transparent, fair and international level assessments.

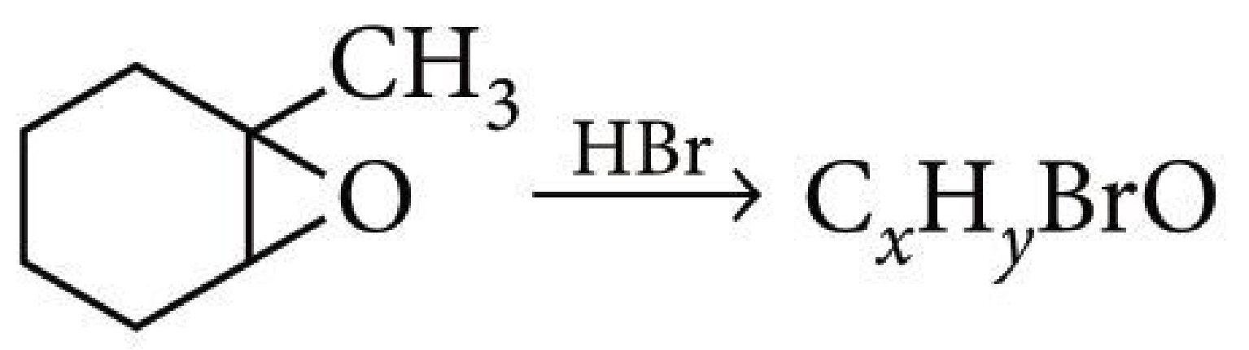
For the **Academic year 2023-24,** following is the Calendar for some major examinations to be conducted by the NTA:

S.No.	Name of Examination	Dates of Examinations	Reserve Dates
1.	Joint Entrance Examination [JEE (Main)] – 2023 Session 1	24, 25, 27, 28, 29, 30, 31 January 2023	01, 02, 03 February 2023
2.	Joint Entrance Examination [JEE (Main)] – 2023 Session 2	06, 08, 10, 11, 12 April 2023	13, 15 April 2023
3.	ICAR AIEEA 2023	26, 27, 28, 29 April 2023	
4.	National Eligibility cum Entrance Test [NEET (UG)] – 2023	07 May 2023	
5.	Common University Entrance Test (CUET) 2023	21 to 31 May 2023	01 to 07 June 2023

For further clarification related to the examination dates and other instructions, the Candidates are advised to visit the official website of NTA www.nta.ac.in for the latest updates.

22. In the estimation of phosphorus in an organic compound by the Carius method, 2.79 g of the compound gave 1.332 g of magnesium pyrophosphate ($Mg_2P_2O_7$). The percentage of phosphorus in the compound is ________.

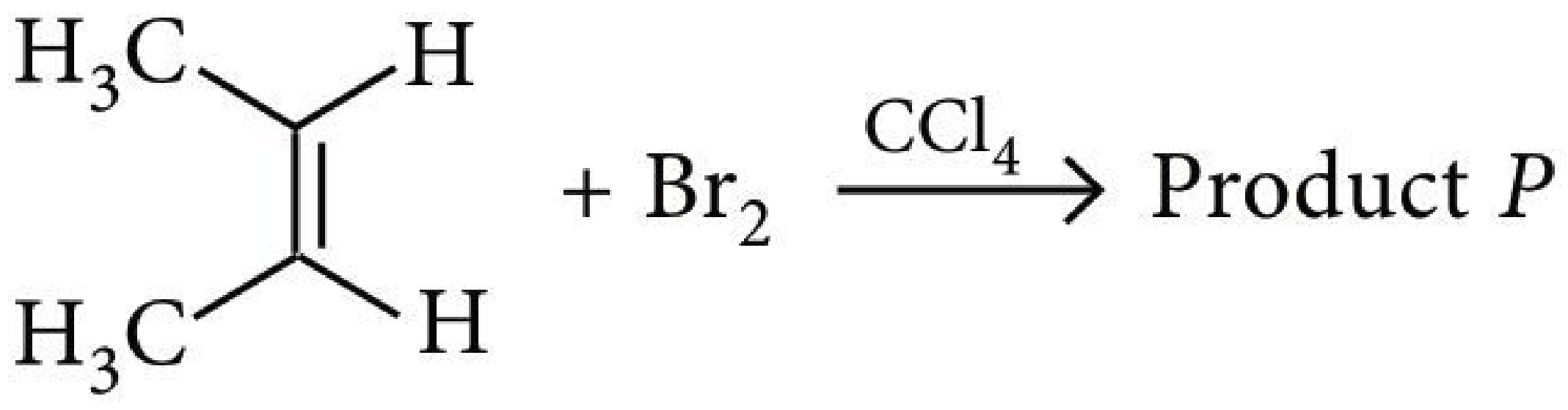
23. Consider the given reaction,



CH3
O
HBr
CxHyBrO

Here, value of $x \times y$ is ________.

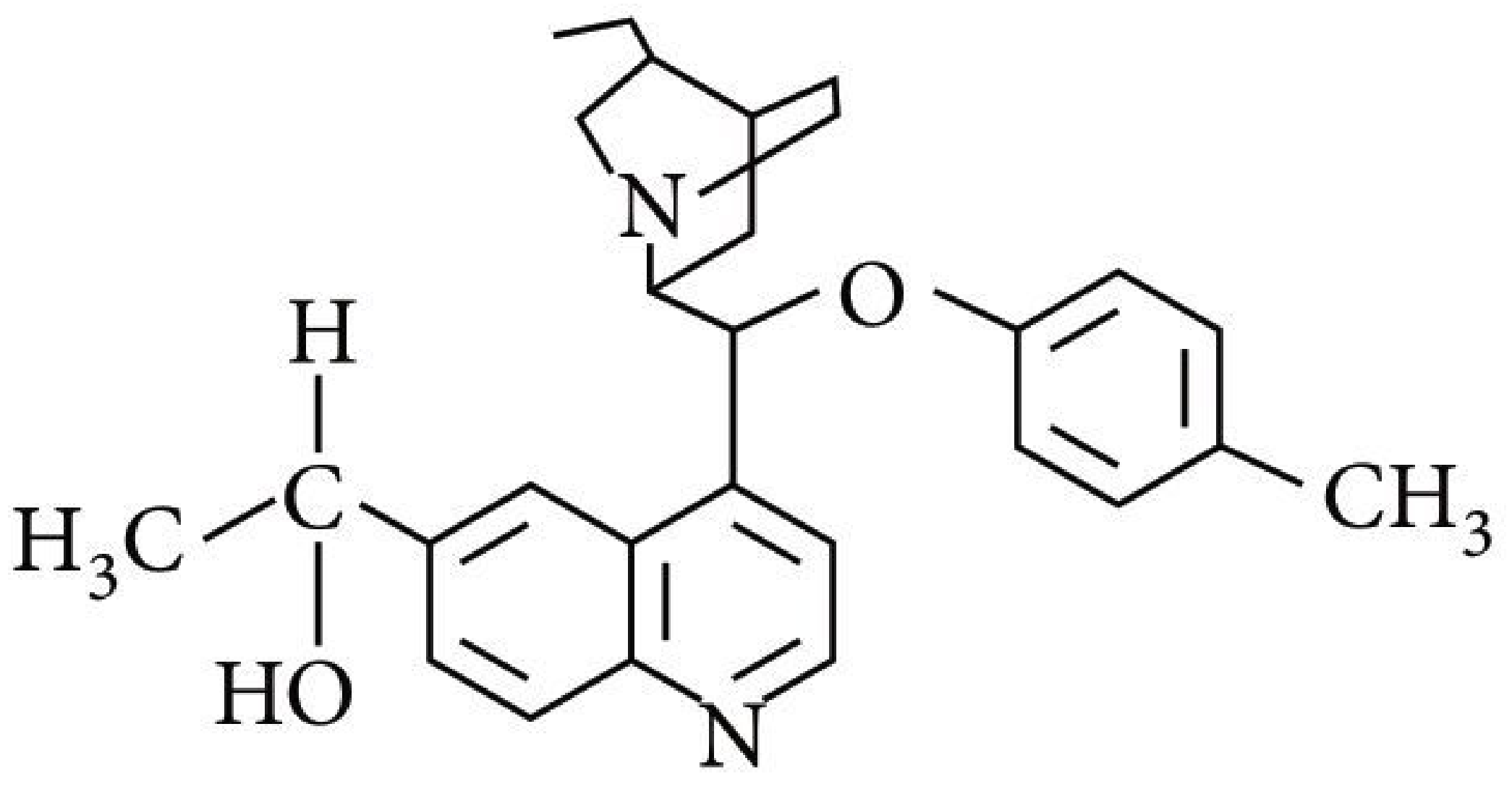
24.



H3C
H
H3C
H
+ Br2
CCl4
Product P

Consider the above chemical reaction. The total number of stereoisomers possible for product 'P' is ________.

25. The number of chiral carbons present in the molecule given below is ________.



N
O
CH3
H
H3C
C
HO
N

26. The Azimuthal quantum number for the valence electrons of Ga^+ ion is ________.
(Atomic number of Ga = 31)

27. Ziegler – Natta catalyst is $Al_x(C_2H_5)_y + TiCl_z$. The value of $[(x + y) - z]$ is ________.

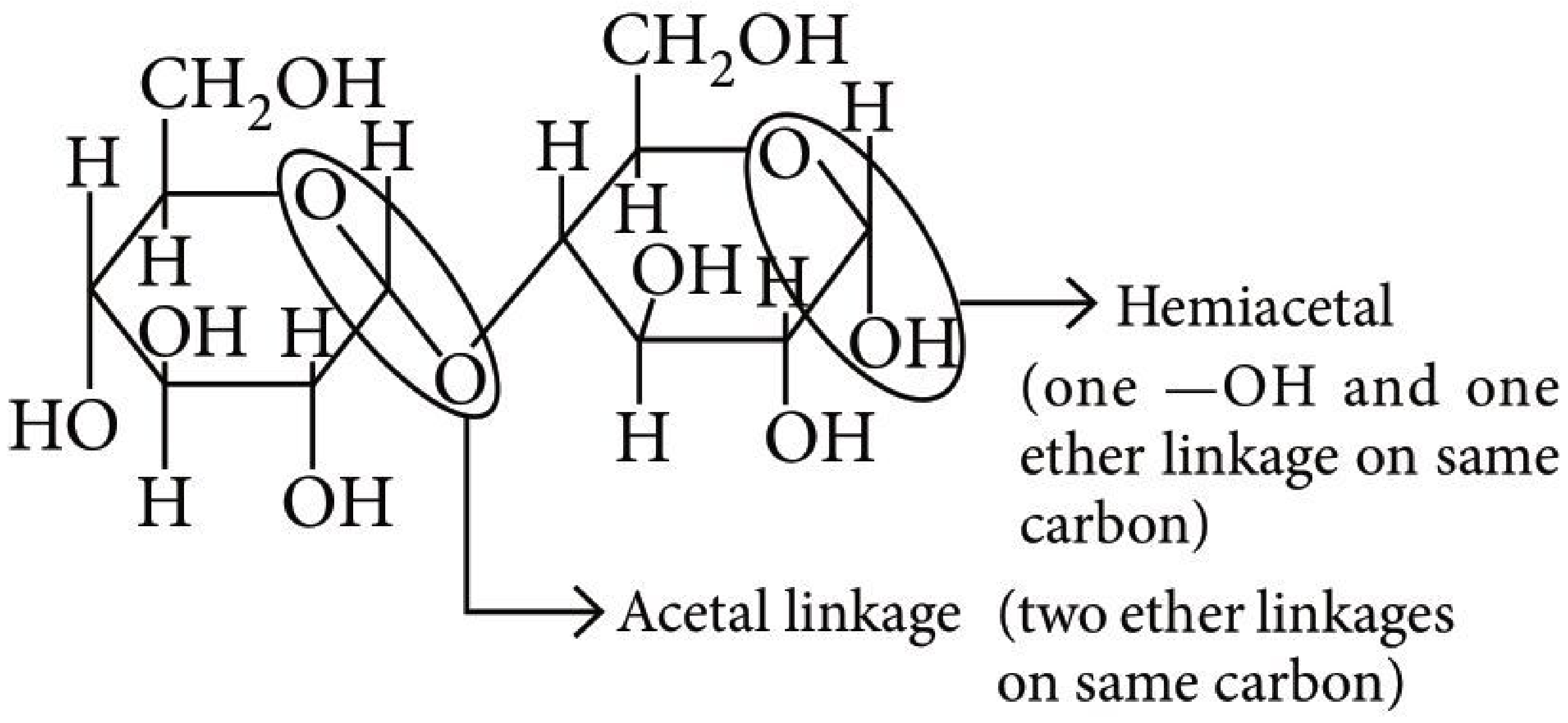
28. The number of molecules among the following which do not satisfy octet rule is ________.
BF_3, $AlCl_3$, H_2O_2, H_2SO_4, HNO_3, PCl_5, CO_2, CO, O_3, NO_2^-

29. At 20°C, the vapour pressure of benzene is 70 torr and that of methyl benzene is 20 torr. The mole fraction of benzene in the vapour phase at 20°C above an equimolar mixture of benzene and methyl benzene is ________ $\times 10^{-2}$. (Nearest Integer)

30. One gram sample of octane C_8H_{18} is burned in excess of oxygen in a bomb calorimeter. The temperature of the calorimeter rises from 294 K to 300 K. If heat capacity of the calorimeter is 8 kJ/K, the energy of combustion of octane (in kJ/K) is ________.

SOLUTIONS

1. (c) : Structure of maltose :



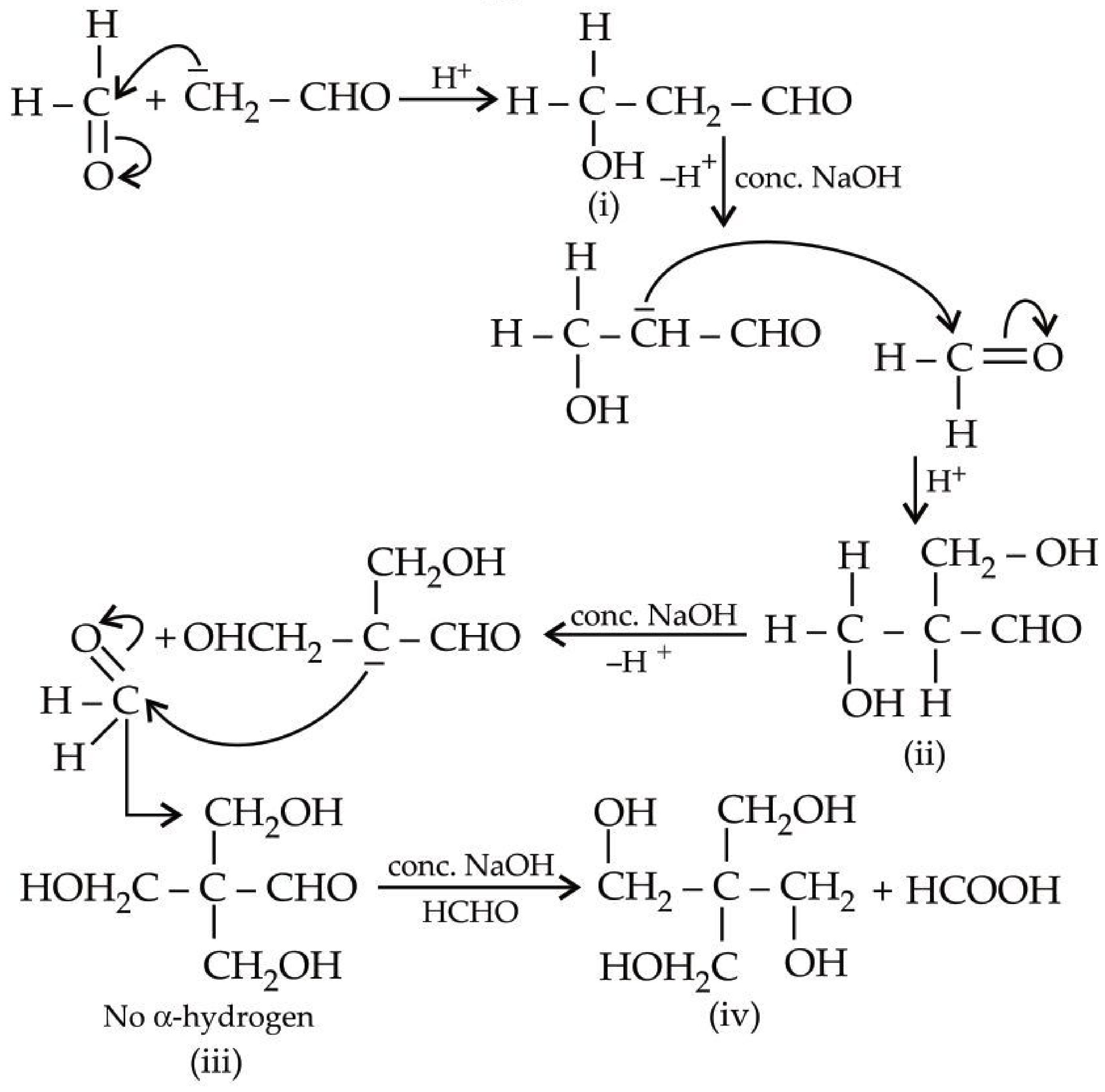
CH2OH
CH2OH
H
O
H
H
OH
H
HO
H
OH
O
H
OH
H
OH
→ Hemiacetal
(one —OH and one ether linkage on same carbon)
→ Acetal linkage
(two ether linkages on same carbon)

2. (d): In a body-centred cubic (*bcc*) lattice, oppositely charged ions touch each other along the body diagonal of the cube. In case of CsCl, Cs^+ ion is in contact with Cl^- ion at the nearest distance which is equal to $r_{Cs^+} + r_{Cl^-} = \frac{\sqrt{3}}{2}a$

3. (d)

4. (c) : Classical smog is formed when there is high concentration of sulphur dioxide and particulate matter produced due to combustion of fuels.

5. (c) : $CH_3CHO \xrightarrow[-H^+]{\text{conc. NaOH}} \bar{C}H_2-CHO$



H–C(=O)H + C̄H2–CHO
H+
H–CH(OH)–CH2–CHO
(i)
–H+
conc. NaOH
H–CH(OH)–C̄H–CHO
H–C(H)=O
H+
H–CH(OH)–CH(CH2–OH)–CHO
(ii)
conc. NaOH
–H+
O=CH2 + OHCH2–C̄(CH2OH)–CHO
HOH2C–C(CH2OH)2–CHO
No α-hydrogen
(iii)
conc. NaOH
HCHO
CH2(OH)–C(CH2OH)(HOH2C)–CH2OH + HCOOH
(iv)

6. (b): Biuret test is used to characterise the presence of —CONH— group in a compound.

7. (b)

8. (b): K reacts with oxygen to form superoxide.
$K + O_2 \longrightarrow KO_2$

9. (b) **10. (c)** **11. (d)** **12. (d)**

13. (c) : In solid state, PCl_5 exists as ionic molecule containing $[PCl_4]^+$ and $[PCl_6]^-$ ions.

14. (d): $\Delta n_g = n_p - n_r = 1 - 3/2$

$\Delta n_g = -1/2$. Hence $K_p = K_c(RT)^{-1/2}$

15. (d): Smelting is process of reducing metal oxide to metal.

16. (c) : $PV = nRT$

At constant temperature and pressure, $\frac{V_1}{V_2} = \frac{n_1}{n_2}$

Say V_1 is volume of N_2 and V_2 is volume of O_2. Then,

$$\frac{1}{7/8} = \frac{m_{N_2}}{\text{Molar mass of } N_2} \times \frac{\text{Molar mass of } O_2}{m_{O_2}}$$

$$\frac{8}{7} = \frac{m_{N_2}}{28} \times \frac{32}{m_{O_2}} \Rightarrow m_{N_2} = m_{O_2}$$

17. (b)

18. (d) :

		13th	14th	15th
2nd period	$2s^22p^1$	B	C	N
3rd period	$3s^23p^1$	Al	Si	P
4th period	$4s^24p^1$	Ga	Ge	As
5th period	$5s^25p^1$	In	Sn	Sb

That element is $_{50}$Sn $\Rightarrow$ [Kr]$4d^{10}\,5s^2\,5p^2$

19. (a)

20. (d): Number of atoms = Moles × N_A

Number of moles $= \frac{\text{wt.}}{\text{Mol. wt.}}$

4 g He = 4/4 = 1 mole ; 46 g Na = 46/23 = 2 moles

0.40 g Ca = 0.40/40 = 0.01 mole

12 g He = 12/4 = 3 moles

Hence, 12 g He contains the greatest number of atoms.

21. (60) : $Q = I \times t = 2 \times 8 \times 60$ C = 960 C

$Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$

6 × 96000 C deposit Cr = 104 g

$\therefore$ 960 C will deposit Cr $= \frac{104 \times 960}{6 \times 96000}$ g = 0.173 g

The amount of Cr^{3+} obtained was 0.104 g

$$\text{Efficiency} = \frac{w_{\text{actual}}}{w_{\text{theoretical}}} \times 100 = \frac{0.104}{0.173} \times 100 = 60\%$$

22. (13.33) : Mass of organic compound = 2.79 g

Mass of $Mg_2P_2O_7$ = 1.332 g

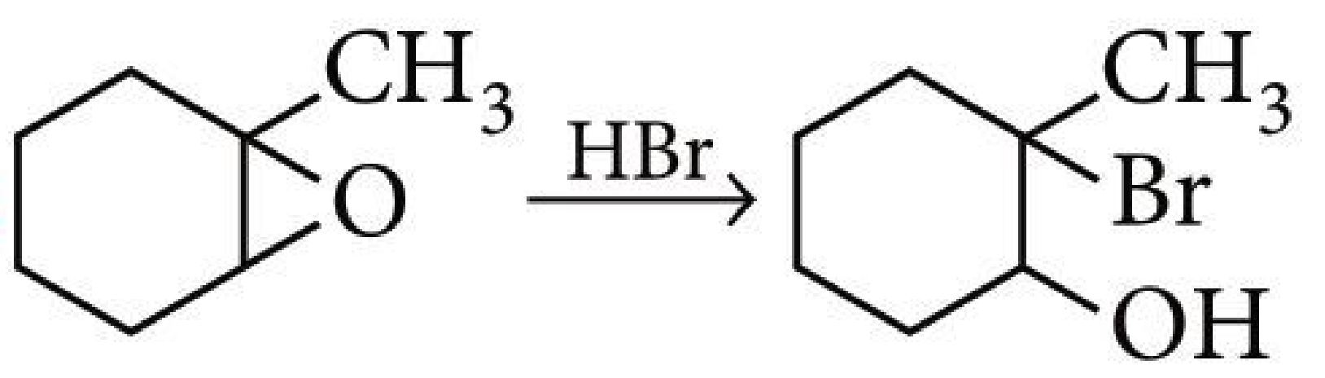
222 g of $Mg_2P_2O_7$ contains 62 g of phosphorus.

$\therefore$ 1.332 g $Mg_2P_2O_7$ contains $\frac{62}{222} \times 1.332$ g of phosphorus.

Since, 2.79 g of the organic compound contains $\frac{62}{222} \times 1.332$ g of phosphorus

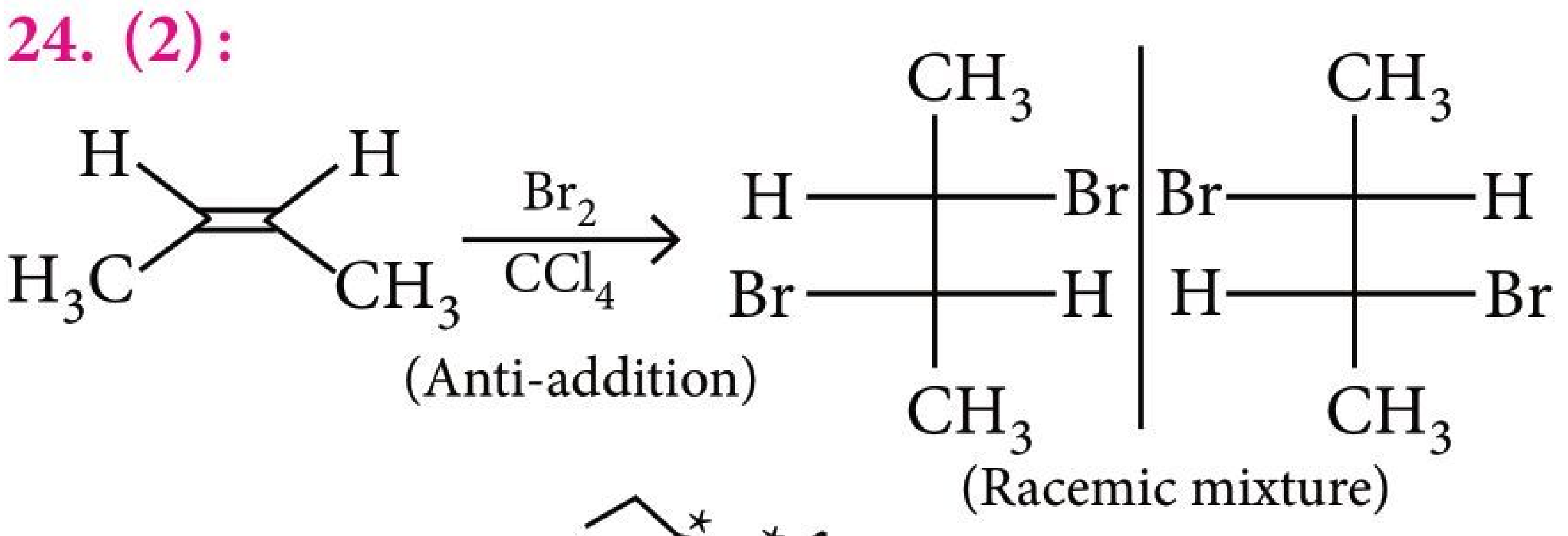
$\therefore$ 100 g of the organic compounds contains $\frac{62}{222} \times \frac{1.332}{2.79} \times 100 = 13.33\%$ of phosphorus.

23. (91) :

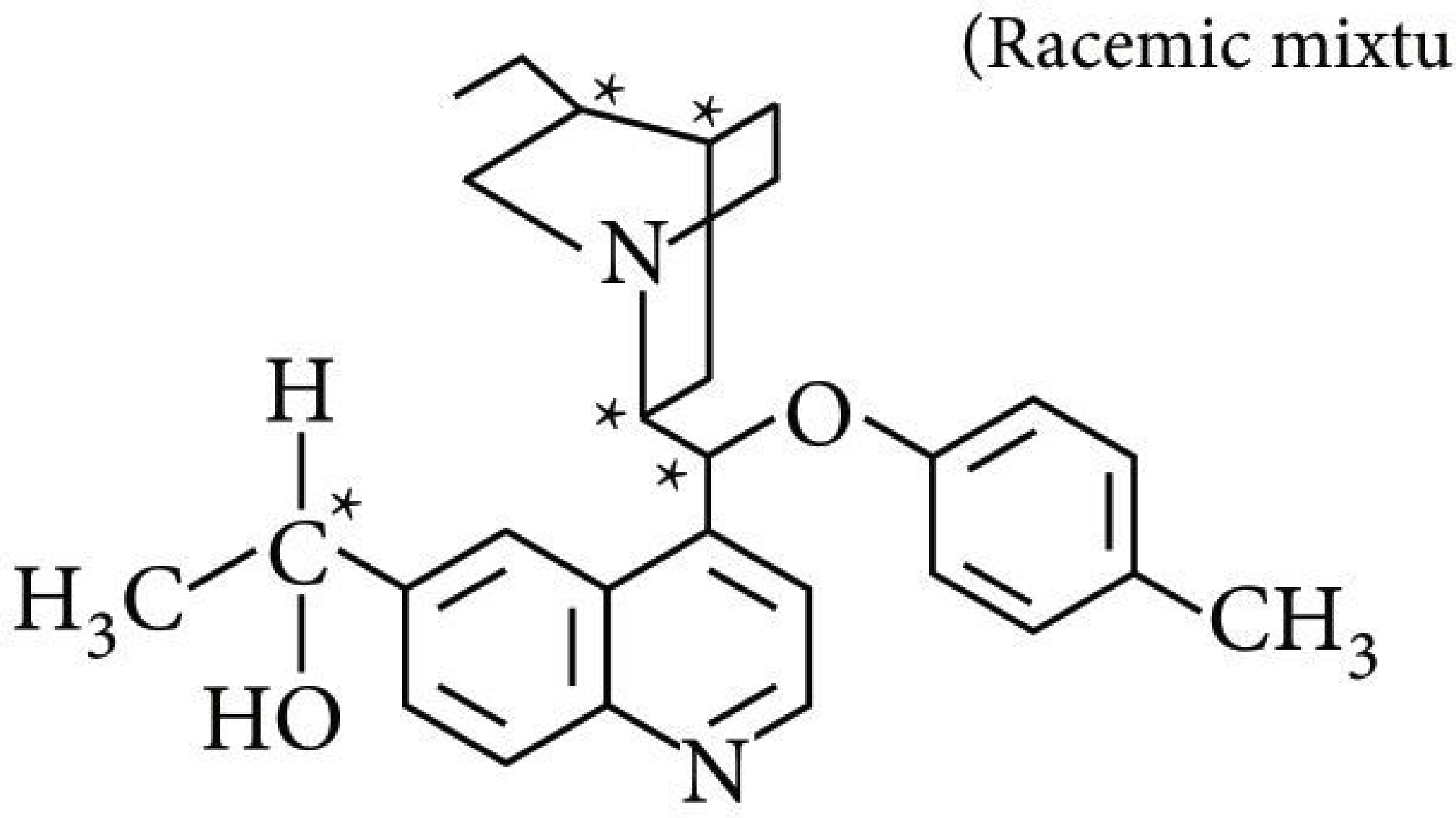


$x = 7, y = 13 \Rightarrow x \times y = 13 \times 7 = 91$

24. (2) :



25. (5) :



26. (0) : Ga : $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^1$

Ga^+ : $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2$

Valence electrons are in *s*-orbital.

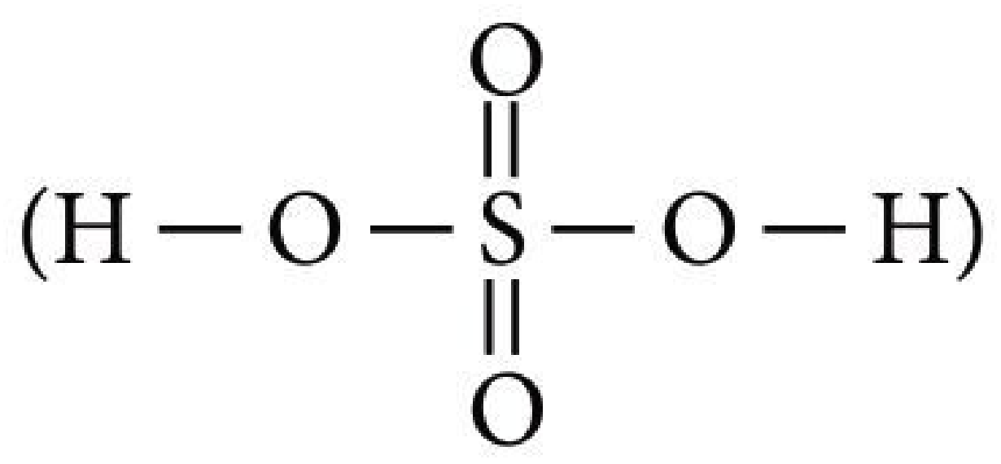
So, Azimuthal quantum number (l) for valence shell electrons is 0.

27. (4) : Ziegler – Natta catalyst is $Al_2(C_2H_5)_6 + TiCl_4$

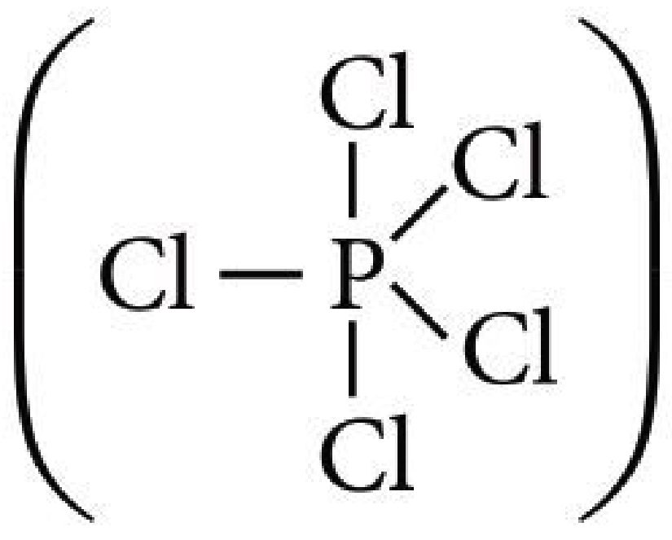
$\therefore$ $x = 2$; $y = 6$; $z = 4$

$[(x + y) - z] = [(2 + 6) - 4] = 4$

28. (4) : BF_3 and $AlCl_3$ are electron deficient whereas

H_2SO_4  and

$(H-O-\overset{\overset{\displaystyle O}{\|}}{\underset{\underset{\displaystyle O}{\|}}{S}}-O-H)$

PCl_5  are hypervalent

(more than 8 electrons around the central atom).

29. (78) : $p_{\text{Total}} = p^\circ_{\text{Benzene}}\, x_{\text{Benzene}} + p^\circ_{\text{Toluene}}\, x_{\text{Toluene}}$

$$= (70)\frac{1}{2} + (20)\frac{1}{2} = 35 + 10 = 45$$

$p_{\text{Benzene}} = p_{\text{Total}}\, y_{\text{Benzene}}$

$$y_{\text{Benzene}} = \frac{70 \times 1/2}{45} = \frac{35}{45} = 0.777 \approx 0.78 = 78 \times 10^{-2}$$

30. (5472) : Rise in temperature = 300 – 294 = 6 K

Heat given to the calorimeter = Heat capacity × ΔT
= 8 × 6 = 48 kJ

Molar mass of octane (C_8H_{18}) = 114

1 g of octane gives = 48 kJ of heat

114 g of octane = 1 mol of octane gives 48 × 114 kJ
= 5472 kJ/mol

◆◆

CHAPTERWISE PRACTICE PAPER 2023

CUET (UG)

Exam on
21st to 31st
May 2023

SERIES - V Coordination Compounds

Section II of CUET (UG) is domain specific. In this section of Chemistry 40 questions to be attempted out of 50.

Time Allowed : 45 Minutes **Maximum Marks :** 200

Multiple Choice Questions (MCQs)

1. The correct IUPAC name of the coordination compound $K_3[Fe(CN)_5NO]$ is
(a) potassium pentacyanidonitrosylferrate(II)
(b) potassium pentacyanidonitroferrate(III)
(c) potassium nitritopentacyanidoferrate(IV)
(d) potassium nitritepentacyanidoiron(II).

2. Which of the following ligands form a chelate?
(a) Acetate (b) Oxalate
(c) Cyanide (d) Ammonia

3. $Fe(CN)_6]^{4-}$ and $[Fe(H_2O)_6]^{2+}$ show different colours in dilute solution because
(a) CN^- is a strong field ligand and H_2O is a weak field ligand hence magnitude of CFSE is different
(b) both CN^- and H_2O absorb same wavelength of energy
(c) complexes of weak field ligands are generally colourless
(d) the sizes of CN^- and H_2O are different hence their colours are also different.

4. The magnitude of magnetic moment (spin only) of $[NiCl_4]^{2-}$ will be
(a) 2.82 B.M. (b) 0
(c) 1.23 B.M. (d) 5.64 B.M.

5. The denticity of ethylenediaminetetra-acetate ion is
(a) 4 (b) 5
(c) 6 (d) none of these.

6. Which of the following statements is correct about $[Co(H_2O)_6]^{2+}$ complex?
(a) Electronic configuration = $3d^7 \rightarrow t_{2g}^5 e_g^2$, no. of unpaired electrons = 3, μ = 3.87 B.M.
(b) Electronic configuration = $3d^6 \rightarrow t_{2g}^4 e_g^2$, no. of unpaired electrons = 2, μ = 2.87 B.M.
(c) Electronic configuration = $3d^7 \rightarrow t_{2g}^6 e_g^1$, no. of unpaired electrons = 1, μ = 2.87 B.M.
(d) Electronic configuration = $3d^7 = t_{2g}^3 e_g^4$, no. of unpaired electrons = 3, μ = 3.87 B.M.

7. Among the following, which are ambidentate ligands?
(i) SCN^- (ii) NO_3^-
(iii) NO_2^- (iv) $C_2O_4^{2-}$
(a) (i) and (iii) (b) (i) and (iv)
(c) (ii) and (iii) (d) (ii) and (iv)

8. According to Werner's theory of coordination compounds
(a) primary valency is ionisable
(b) secondary valency is ionisable
(c) primary and secondary valencies are ionisable
(d) neither primary nor secondary valency is ionisable.

9. Which of the following descriptions about $[FeCl_6]^{4-}$ is correct?
(a) sp^3d, inner orbital complex, diamagnetic
(b) sp^3d^2, outer orbital complex, paramagnetic
(c) d^2sp^3, inner orbital complex, paramagnetic
(d) d^2sp^3, outer orbital complex, diamagnetic

10. The one that is not expected to show isomerism is
(a) $[Ni(NH_3)_4(H_2O)_2]^{2+}$ (b) $[Ni(NH_3)_2Cl_2]$
(c) $[Ni(en)_3]^{2+}$ (d) $[Pt(NH_3)_2Cl_2]$

11. Which of the following complexes will show geometrical isomerism ?
(a) Potassium amminetrichloroplatinate(II)
(b) Aquachlorobis(ethylenediamine)cobalt(II) chloride
(c) Potassium tris(oxalato)chromate(III)
(d) Pentaaquachlorochromium(III) chloride

12. The IUPAC name of $[Co(NH_3)_4Cl(NO_2)]Cl$ is
(a) tetraamminechloridonitrito-N-cobalt(III) chloride
(b) tetraamminechloridonitrocobalt(II) chloride
(c) tetraamminechloridonitrocobalt(I) chloride
(d) tetraamminechloridonitrocobalt(III) chloride.

13. EDTA can form complex with how many number of donor atoms?
(a) One
(b) Two
(c) Six
(d) Three

14. The coordination number and the oxidation state of the central metal ion in the complex ion $[CrCl_2(ox)_2]^{3-}$ are respectively,
(a) 4 and –3
(b) 6 and +3
(c) 4 and +3
(d) 6 and –3

15. Which of the following complexes has minimum magnetic moment value?
(a) $[Fe(CN)_6]^{3-}$
(b) $[Mn(H_2O)_6]^{2+}$
(c) $[NiCl_4]^{2-}$
(d) $[Co(H_2O)_6]^{+}$

16. Which of the following systems has maximum number of unpaired electrons?
(a) d^6 (tetrahedral, high spin)
(b) d^9 (octahedral)
(c) d^4 (octahedral, low spin)
(d) d^7 (octahedral, high spin)

17. The correct order of spin-only magnetic moments among the following is
(Atomic number : Mn = 25, Co = 27, Ni = 28, Zn = 30)
(a) $[ZnCl_4]^{2-} > [NiCl_4]^{2-} > [CoCl_4]^{2-} > [MnCl_4]^{2-}$
(b) $[CoCl_4]^{2-} > [MnCl_4]^{2-} > [NiCl_4]^{2-} > [ZnCl_4]^{2-}$
(c) $[MnCl_4]^{2-} > [CoCl_4]^{2-} > [NiCl_4]^{2-} > [ZnCl_4]^{2-}$
(d) $[NiCl_4]^{2-} > [CoCl_4]^{2-} > [MnCl_4]^{2-} > [ZnCl_4]^{2-}$

18. Which order is correct in spectrochemical series of ligands?
(a) $Cl^- < F^- < C_2O_4^{2-} < NO_2^- < CN^-$
(b) $CN^- < C_2O_4^{2-} < Cl^- > NO_2^- < F^-$
(c) $C_2O_4^{2-} < F^- < Cl^- > NO_2^- < CN^-$
(d) $F^- < Cl^- < NO_2^- < CN^- < C_2O_4^{2-}$

19. Which of the following has a square planar geometry?
(At. nos. : Fe = 26, Co = 27, Ni = 28, Pt = 78)
(a) $[PtCl_4]^{2-}$
(b) $[CoCl_4]^{2-}$
(c) $[FeCl_4]^{2-}$
(d) $[NiCl_4]^{2-}$

20. Which is/are low spin complex(es)?
(a) $[CoF_6]^{3-}$
(b) $[Fe(CN)_6]^{3-}$
(c) $[Fe(CN)_6]^{4-}$
(d) Both (b) and (c)

21. Which of the following statements is true?
(a) If $\Delta_o > P$, strong field ligands and low spin complexes.
(b) If $\Delta_o < P$, strong field ligands and high spin complexes.
(c) If $\Delta_o > P$, weak field ligands and low spin complexes.
(d) If $\Delta_o < P$, weak field ligands and low spin complexes.

22. The pair in which both species have same magnetic moment (spin only value) is
(a) $[Cr(H_2O)_6]^{2+}$, $[CoCl_4]^{2-}$
(b) $[Cr(H_2O)_6]^{2+}$, $[Fe(H_2O)_6]^{2+}$
(c) $[Mn(H_2O)_6]^{2+}$, $[Cr(H_2O)_6]^{2+}$
(d) $[CoCl_4]^{2-}$, $[Fe(H_2O)_6]^{2+}$

23. In $Fe(CO)_5$, the Fe – C bond possesses
(a) π-character only
(b) both σ and π characters
(c) ionic character
(d) σ-character only.

24. Wilkinson's catalyst is used for
(a) epoxidation
(b) hydrogenation
(c) polymerisation
(d) substitution.

25. Select the true statement from the following for metal carbonyls?
(a) π back bonding strengthens M – C bond order as well as CO bond order.
(b) π back bonding weakens M – C bond order as well as CO bond order.
(c) π back bonding weakens M – C bond order but strengthens CO bond order.
(d) π back bonding strengthens M – C bond order and weakens CO bond order.

26. $[Co(NH_3)_4Cl_2]NO_2$ and $[Co(NH_3)_4Cl(NO_2)]Cl$ exhibit which type of isomerism?
(a) Geometrical
(b) Optical
(c) Linkage
(d) Ionization

27. Among $[Fe(H_2O)_6]^{3+}$, $[Fe(CN)_6]^{3-}$, $[FeCl_6]^{3-}$ species, the hybridisation state of the Fe atom are, respectively
(a) $d^2sp^3, d^2sp^3, sp^3d^2$
(b) $sp^3d^2, d^2sp^3, d^2sp^3$
(c) $sp^3d^2, d^2sp^3, sp^3d^2$
(d) none of the above.

28. Among the complexes of Ni listed below, the following is the only correct statement.
I. $[Ni(CO)_4]$
II. $[Ni(CN)_4]^{2-}$
III. $[NiCl_4]^{2-}$

(a) All of them have tetrahedral geometry.
(b) I and III are tetrahedral and II has square planar geometry.
(c) I and II are tetrahedral and III is square planar.
(d) All of them have square planar geometry.

29. Considering H_2O as a weak field ligand, the number of unpaired electrons in $[Mn(H_2O)_6]^{2+}$ will be (atomic number of Mn = 25)
(a) three (b) five (c) two (d) four.

30. The number of unpaired electrons in the complex ion $[CoF_6]^{3-}$ is (atomic number of Co = 27)
(a) 2 (b) 3 (c) 4 (d) 0

31. Colour of transition metal complexes can be explained by
(a) completely filled *d*-orbitals
(b) vacant *d*-orbitals
(c) *d*-*d* transition
(d) none of these

32. Which is a high spin complex?
(a) $[CoF_6]^{3-}$ (b) $[Co(NH_3)_6]^{3+}$
(c) $[Mn(CN)_6]^{3-}$ (d) None of these

33. Amongst the following ions, which one has the highest paramagnetism?
(a) $[Cr(H_2O)_6]^{3+}$ (b) $[Fe(H_2O)_6]^{2+}$
(c) $[Cu(H_2O)_6]^{2+}$ (d) $[Zn(H_2O)_6]^{2+}$

34. Out of TiF_6^{2-}, CoF_6^{3-}, Cu_2Cl_2 and $NiCl_4^{2-}$ (*Z* of Ti = 22, Co = 27, Cu = 29, Ni = 28) the coloured species are
(a) Cu_2Cl_2 and $NiCl_4^{2-}$ (b) TiF_6^{2-} and Cu_2Cl_2
(c) CoF_6^{3-} and $NiCl_4^{2-}$ (d) TiF_6^{2-} and CoF_6^{3-}.

Assertion & Reason Based MCQs

For question numbers 35-38, a statement of Assertion followed by a statement of Reason is given. Choose the correct answer out of the following choices.

(a) If both assertion and reason are correct and reason is the correct explanation of assertion.
(b) If both assertion and reason are correct but reason is not the correct explanation of assertion.
(c) If assertion is correct but reason is wrong.
(d) If assertion is wrong but reason is correct.

35. **Assertion :** Coordination number of Fe and Co in $[Fe(C_2O_4)_3]^{3-}$ and $[Co(en)_3]^{3+}$ is 6.
Reason : $C_2O_4^{2-}$ and *en* (ethane-1,2-diamine) are didentate ligands.

36. **Assertion :** Geometrical isomerism is also called *cis-trans* isomerism.
Reason : Tetrahedral complexes show geometrical isomerism.

37. **Assertion :** In tetrahedral complexes low spin configurations are rarely observed.
Reason : Δ_t is smaller as compared to Δ_o, $\Delta_t = \left(\frac{4}{9}\right)\Delta_o$

38. **Assertion :** Inner orbital complexes are low spin complexes.
Reason : In low spin complexes, inner *d*-orbital (3*d*) is used in hybridisation.

Match the Columns

39. Match the coordination compounds given in column I with the central metal atoms given in column II and assign the correct code.

Column I (Coordination Compound)		Column II (Central metal atom)	
(A)	Chlorophyll	(i)	Rhodium
(B)	Haemoglobin	(ii)	Cobalt
(C)	Wilkinson catalyst	(iii)	Calcium
(D)	Vitamin B_{12}	(iv)	Iron
		(v)	Magnesium

(a) (A) → (v); (B) → (iv); (C) → (i); (D) → (ii)
(b) (A) → (iii); (B) → (iv); (C) → (v); (D) → (i)
(c) (A) → (v); (B) → (iii); (C) → (ii); (D) → (i)
(d) (A) → (iii); (B) → (iv); (C) → (i); (D) → (ii)

40. Match the compounds given in column I with the oxidation state of cobalt present in it (given in column II) and assign the correct code.

Column I (Compound)		Column II (Oxidation state of Co)	
(A)	$[Co(NCS)(NH_3)_5]SO_3$	(i)	+ 4
(B)	$[Co(NH_3)_4Cl_2]SO_4$	(ii)	0
(C)	$Na_4[Co(S_2O_3)_3]$	(iii)	+ 1
(D)	$[Co_2(CO)_8]$	(iv)	+ 2
		(v)	+ 3

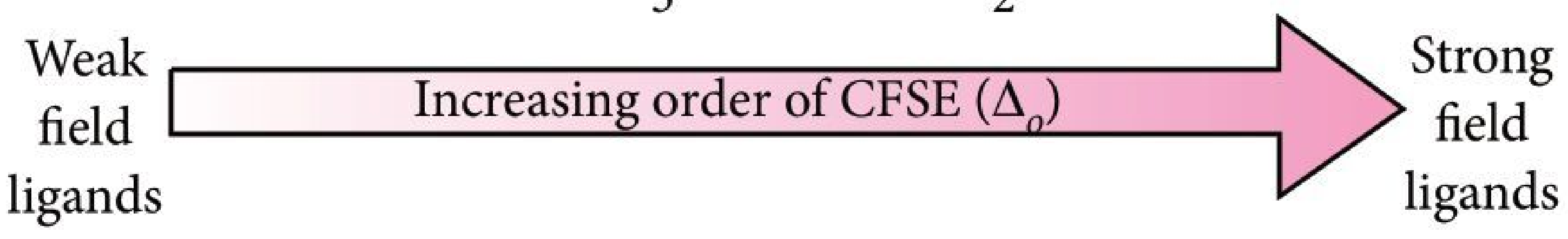
(a) (A) → (i); (B) → (ii); (C) → (iv); (D) → (iii)
(b) (A) → (iv); (B) → (iii); (C) → (ii); (D) → (i)
(c) (A) → (v); (B) → (i); (C) → (iv); (D) → (ii)
(d) (A) → (v); (B) → (i); (C) → (ii); (D) → (iii)

Case Based MCQs

Case I : Read the passage given below and answer the following questions from 41 to 45.

The crystal field splitting, Δ_o, depends upon the field produced by the ligand and charge on the metal ion. Some ligands are able to produce strong fields in which the splitting will be large whereas other ligands produce weak fields which result in small splitting of *d*-orbitals. Ligands are arranged in the order of increasing field strength called spectrochemical series.

$I^- < Br^- < SCN^- < Cl^- < S^{2-} < F^- < OH^- < C_2O_4^{2-} < H_2O <$ $NCS^- < EDTA^{4-} < NH_3 < en < NO_2^- < CN^- < CO$



For complexes in a octahedral field, *d*-orbital occupancy depends on Δ_o and pairing energy, *P*.

The following questions are multiple choice questions. Choose the most appropriate answer :

41. Arrange the following cobalt complexes in the order of increasing Crystal Field Stabilization Energy (CFSE) value.

Complexes : $\underset{A}{[CoF_6]^{3-}}$, $\underset{B}{[Co(H_2O)_6]^{2+}}$, $\underset{C}{[Co(NH_3)_6]^{3+}}$ and $\underset{D}{[Co(en)_3]^{3+}}$

Choose the correct option.

(a) $B < C < D < A$ (b) $B < A < C < D$
(c) $A < B < C < D$ (d) $C < D < B < A$

42. $[Co(C_2O_4)_3]^{3-}$ is a diamagnetic complex because

(a) $C_2O_4^{2-}$ is a strong field ligand hence causes pairing of electrons
(b) $C_2O_4^{2-}$ is a bidentate ligand hence causes pairing of electrons
(c) Co^{3+} is a strong central atom hence in all complexes of Co^{3+} electrons are paired
(d) $C_2O_4^{2-}$ is a strong field ligand hence causes splitting of *d*-orbitals.

43. The complex ion having minimum magnitude of Δ_o(CFSE) is

(a) $[Co(NH_3)_6]^{3+}$ (b) $[Cr(H_2O)_6]^{3+}$
(c) $[Cr(CN)_6]^{3-}$ (d) $[CoCl_6]^{3-}$

44. The crystal field stabilisation energy (CFSE) for $[CoCl_6]^{4-}$ is 18000 cm^{-1}. The CFSE for $[CoCl_4]^{2-}$ will be

(a) 6000 cm^{-1} (b) 16000 cm^{-1}
(c) 18000 cm^{-1} (d) 8000 cm^{-1}

45. The correct electronic configuration of d^4 in low spin state according to Crystal Field Splitting theory is

(a) $t_{2g}^4\, e_g^0$ (b) $t_{2g}^3\, e_g^1$ (c) $t_{2g}^2\, e_g^2$ (d) $t_{2g}^1\, e_g^3$

Case II : Read the passage given below and answer the following questions from 46 to 50.

To explain bonding in coordination compounds various theories were proposed. One of the important theory was valence bond theory. According to that, the central metal ion in the complex makes available a number of empty orbitals for the formation of coordination bonds with suitable ligands. The appropriate atomic orbitals of the metal hybridise to give a set of equivalent orbitals of definite geometry.

The *d*-orbitals involved in the hybridisation may be either inner *d*-orbitals *i.e.*, $(n - 1)d$ or outer *d*-orbitals *i.e.*, *nd*. For example, Co^{3+} forms both inner orbital and outer orbital complexes, with ammonia it forms $[Co(NH_3)_6]^{3+}$ and with fluorine it forms $[CoF_6]^{3-}$ complex ion.

The following questions are multiple choice questions. Choose the most appropriate answer :

46. Which of the following is not true for $[CoF_6]^{3-}$?

(a) It is paramagnetic.
(b) It has coordination number of 6.
(c) It is outer orbital complex.
(d) It involves d^2sp^3 hybridisation.

47. Consider the following two complex ions : $[CoF_6]^{3-}$ and $[Co(C_2O_4)_3]^{3-}$. Which of the following statement(s) is/are false?

I. Both are octahedral.
II. $[Co(C_2O_4)_3]^{3-}$ is diamagnetic while $[CoF_6]^{3-}$ is paramagnetic.
III. Both are outer orbital complexes.
IV. In both the complexes the central metal is in the same oxidation state.

(a) II and III (b) II, III and IV
(c) III only (d) III and IV

48. Which of the following is true for $[Co(NH_3)_6]^{3+}$?

(a) It is an octahedral, diamagnetic and outer orbital complex.
(b) It is an octahedral, paramagnetic and outer orbital complex.
(c) It is an octahedral, paramagnetic and inner orbital complex.
(d) It is an octahedral, diamagnetic and inner orbital complex.

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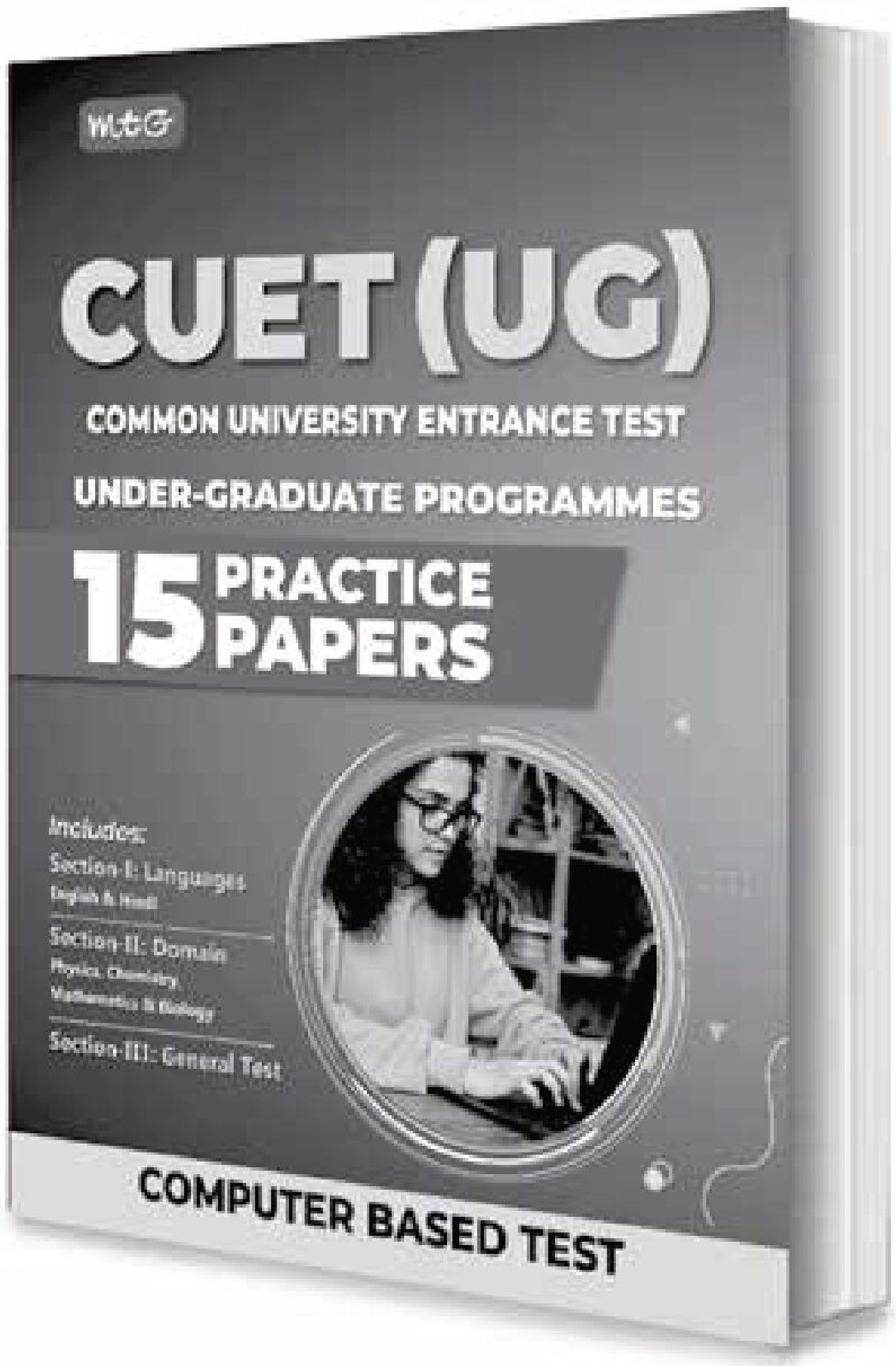
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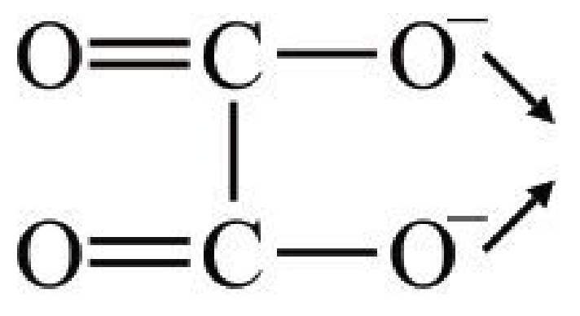
49. The paramagnetism of $[CoF_6]^{3-}$ is due to
(a) 3 electrons (b) 4 electrons
(c) 2 electrons (d) 1 electron.

50. Which of the following is an inner orbital or low spin complex?
(a) $[Ni(H_2O)_6]^{3+}$ (b) $[FeF_6]^{3-}$
(c) $[Co(CN)_6]^{3-}$ (d) $[NiCl_4]^{2-}$

SOLUTIONS

1. (a)

2. (b): Oxalate is a bidentate ligand, hence forms a chelate.



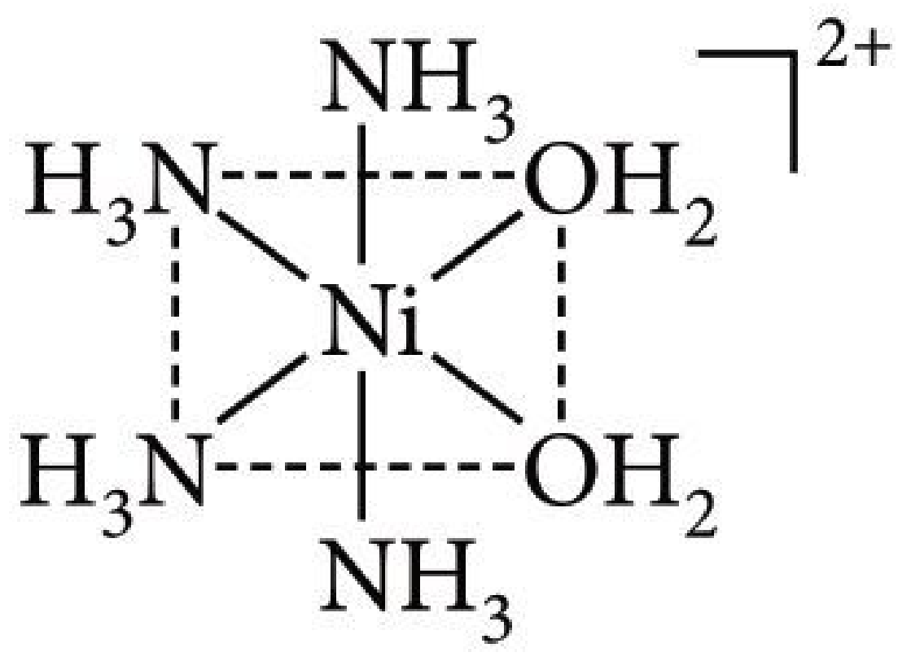
3. (a) **4. (a)** **5. (c)** **6. (a)**

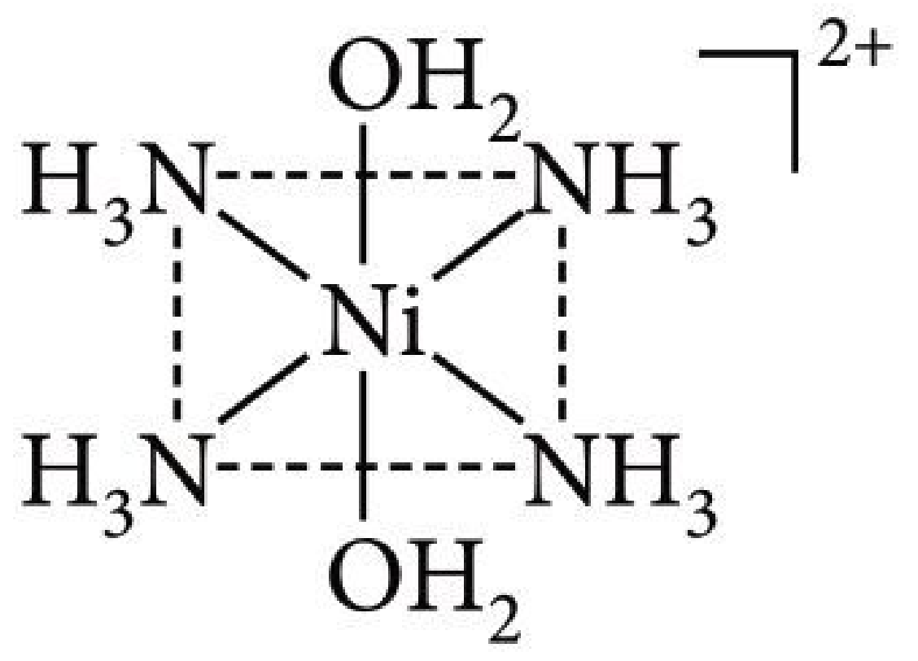
7. (a): SCN^- and NO_2^- are ambidentate ligands, since they have more than one donor atoms to attach to the central metal atom.

8. (a): Primary valency is ionisable according to Werner's theory of coordination compounds.

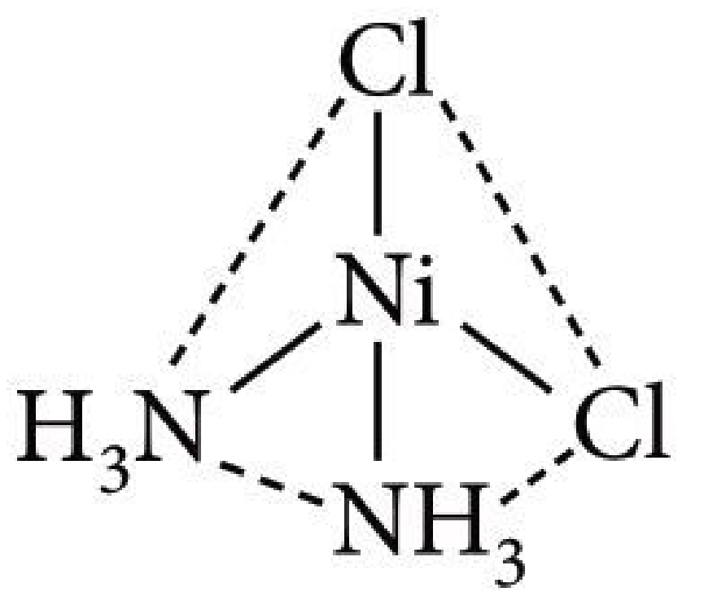
9. (b)

10. (b): $[Ni(NH_3)_4(H_2O)_2]^{2+}$ - Octahedral geometry, exhibits geometrical isomerism (*cis*- and *trans*-isomers).


cis-isomer

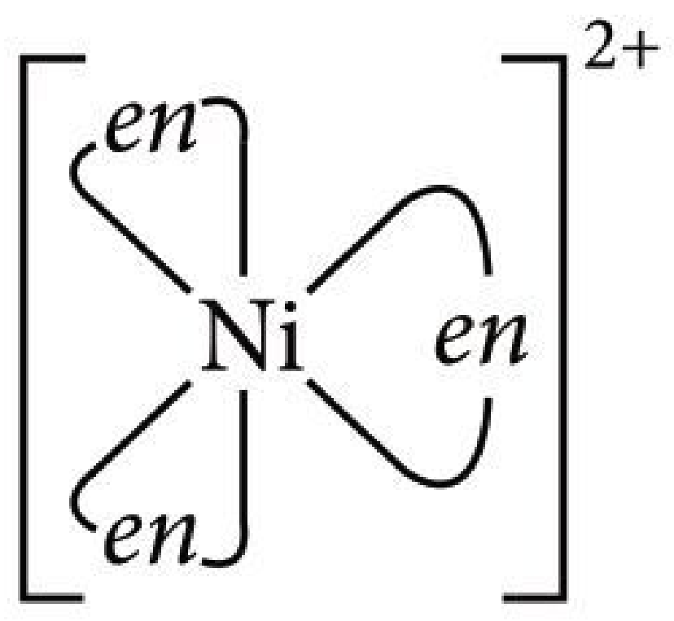

trans-isomer

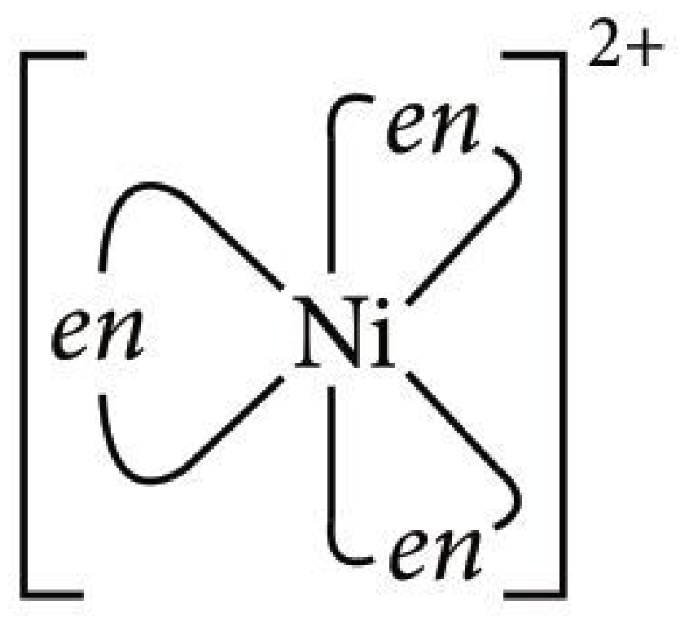
$[Ni(NH_3)_2Cl_2]$–Tetrahedral geometry
$Ni^{2+} : 3d^8 4s^0$


(sp^3 hybridisation)

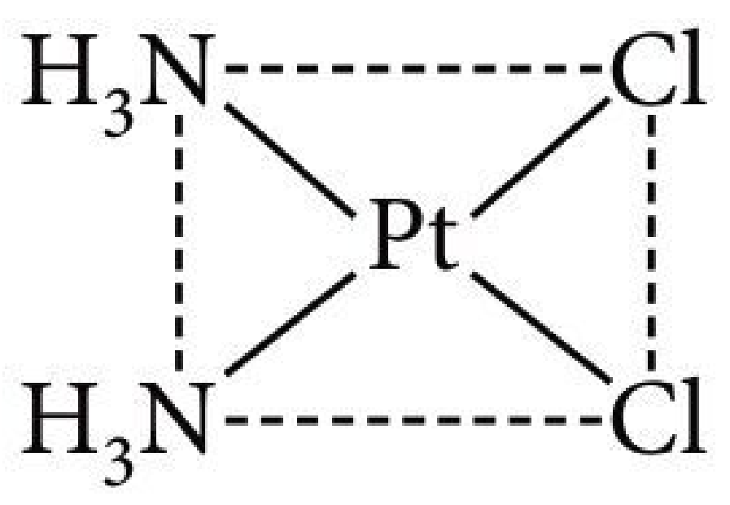
It does not show any isomerism.

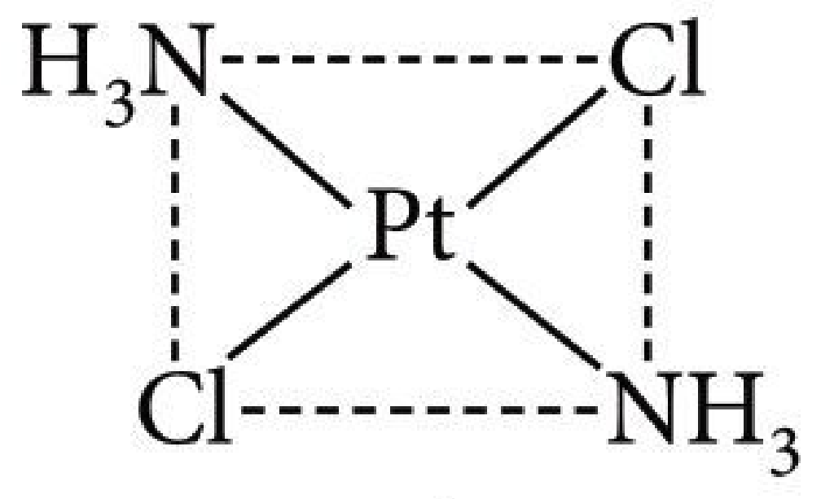
$[Ni(en)_3]^{2+}$ - Octahedral geometry, shows optical isomerism.


d-form

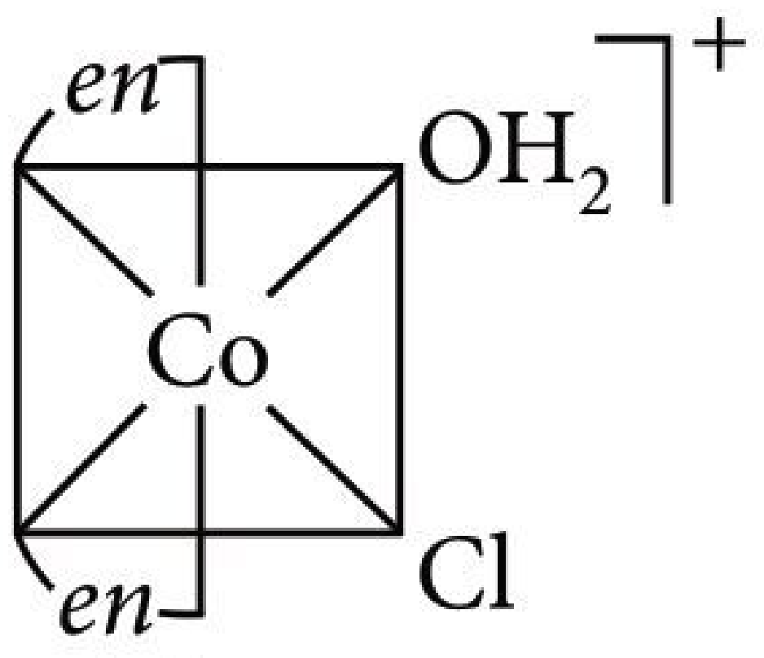

l-form

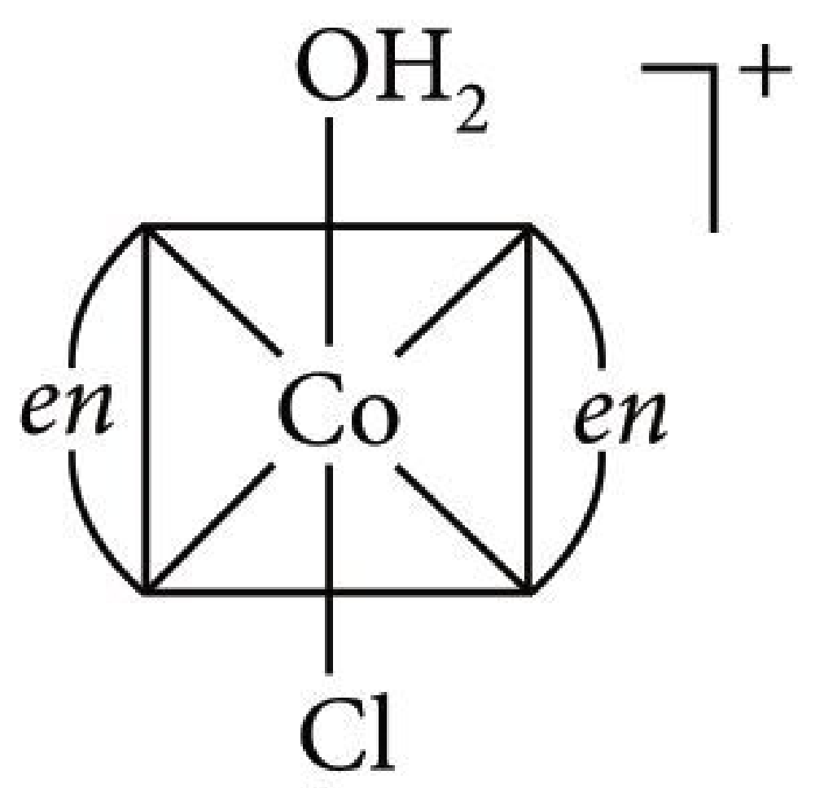
$[Pt(NH_3)_2Cl_2]$ - Square planar geometry. It shows *cis*-*trans*-isomers *i.e.*, geometrical isomerism.


cis-isomer


trans-isomer

11. (b): (a) $K[Pt(NH_3)Cl_3]$: This complex is $[MAB_3]$ type, which does not show geometrical isomerism.
(b) $[Co(H_2O)Cl(en)_2]Cl$: This complex shows geometrical isomerism.


cis-isomer


trans-isomer

(c) $K_3[Cr(ox)_3]$: This complex is $[M(AA)_3]$ type, it does not show geometrical isomerism.
(d) $[Cr(H_2O)_5Cl]\ Cl_2$: This complex is $[MA_5B]$ type. It does not show geometrical isomerism.

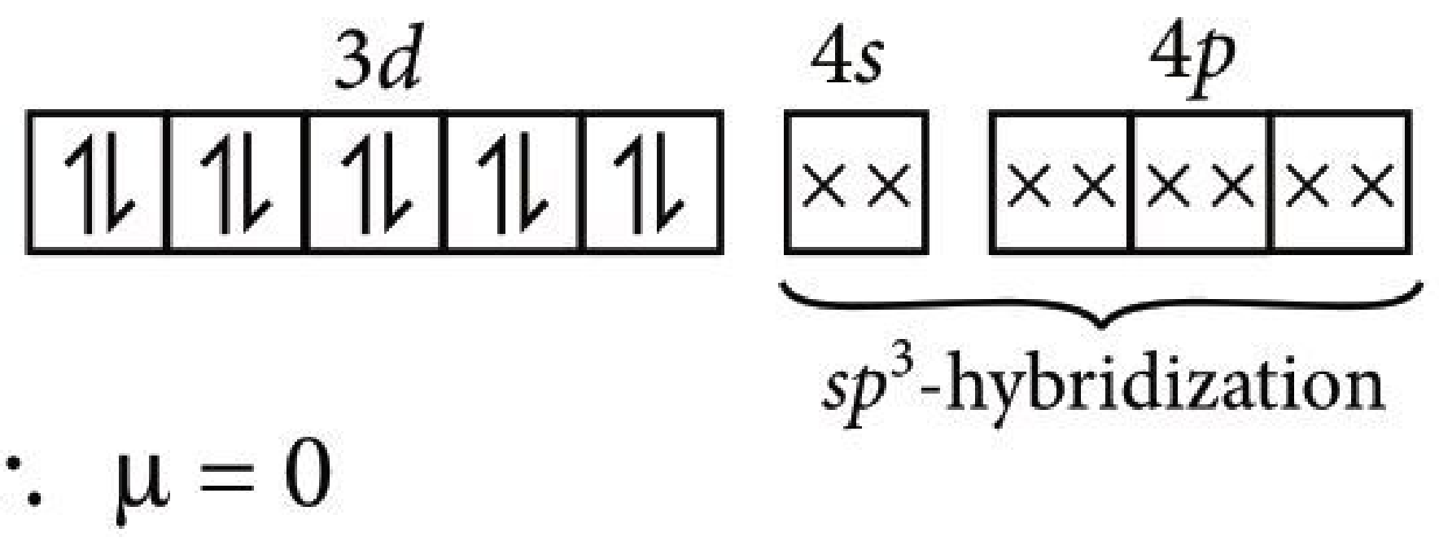
12. (a) **13. (c)**

14. (b): Complex ion : $[CrCl_2(ox)_2]^{3-}$
Coordination number is 6 as oxalato is didentate ligand.
Oxidation state of central metal ion : $x - 2 - 4 = -3$
$\Rightarrow x = +3$

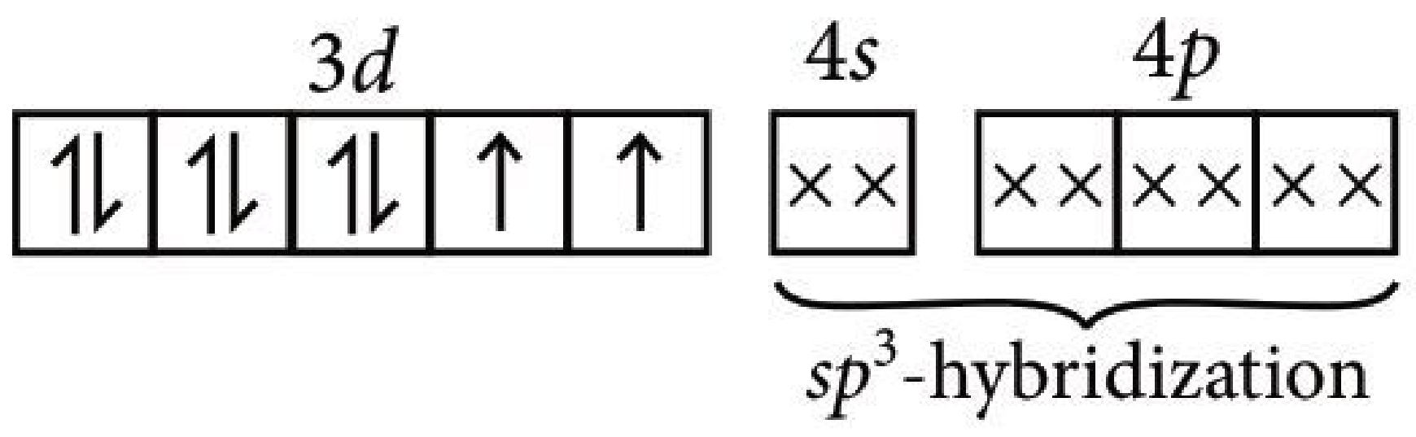
15. (a)

16. (a): Number of unpaired electrons in d^6 (tetrahedral, high spin) = 4
Number of unpaired electrons in d^9 (octahedral) = 1
Number of unpaired electrons in d^4 (octahedral, low spin) = 2
Number of unpaired electrons in d^7 (octahedral, high spin) = 3

17. (c) : Spin-only magnetic moment (μ)
$$= \sqrt{n(n+2)}\ \text{B.M.}$$
Where, n is the number of unpaired electron(s).
As Cl^- is a weak field ligand, no pairing of electrons takes place.
(i) $[ZnCl_4]^{2-} : Zn^{2+} : [Ar]3d^{10}$

$[ZnCl_4]^{2-}$:


$\because n = 0, \therefore \mu = 0$
(ii) $[NiCl_4]^{2-} : Ni^{2+} : [Ar]3d^8$

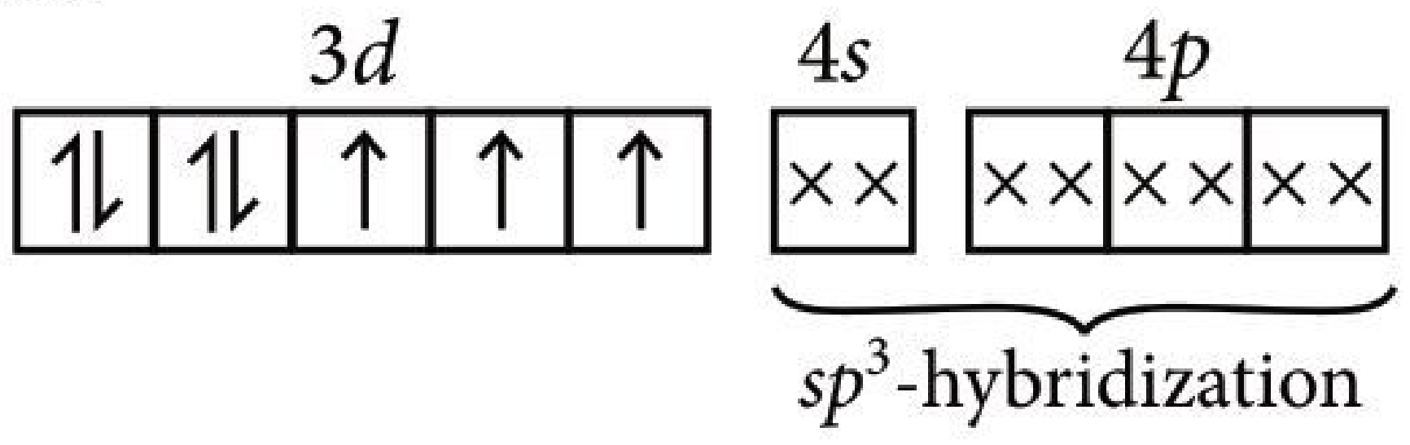
$[NiCl_4]^{2-}$:


∵ $n = 2$, ∴ $\mu = \sqrt{2(2+2)} = 2.83$ B.M.

(iii) $[CoCl_4]^{2-}$:

Co^{2+} : $[Ar]3d^7$

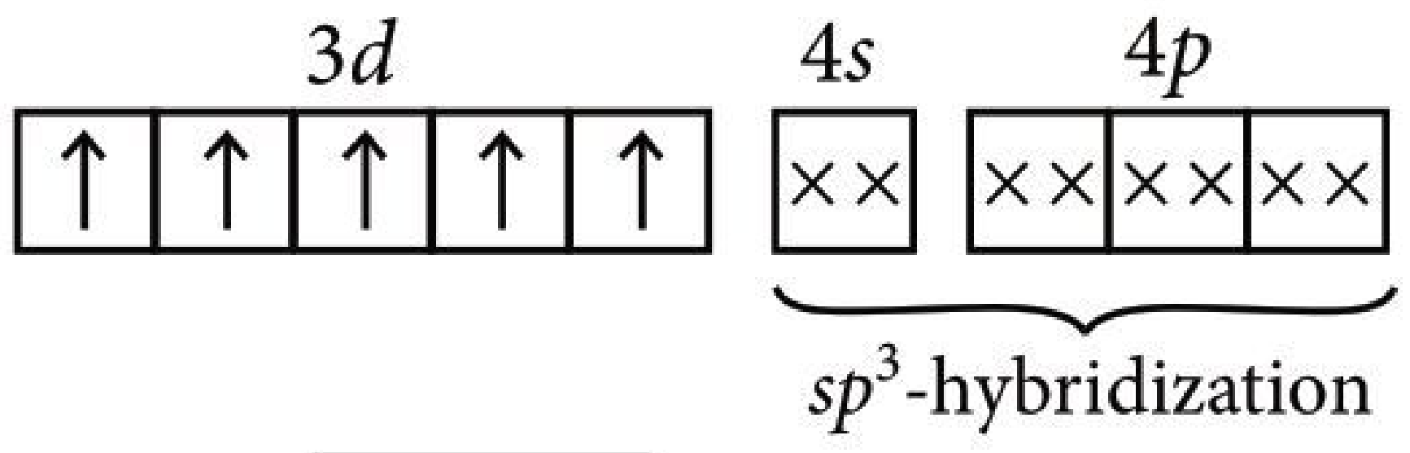
$[CoCl_4]^{2-}$:



∵ $n = 3$, ∴ $\mu = \sqrt{3(3+2)} = 3.87$ B.M.

(iv) $[MnCl_4]^{2-}$: Mn^{2+} : $[Ar]3d^5$

$[MnCl_4]^{2-}$:



∵ $n = 5$, ∴ $\mu = \sqrt{5(5+2)} = 5.91$ B.M.

18. (a) **19. (a)**

20. (d): CN^- being strong field ligand, causes pairing and results in the formation of low spin complex.

21. (a): Strong field ligands cause greater splitting which leads to pairing of electrons.

22. (b): Spin only magnetic moment, $\mu = \sqrt{n(n+2)}$ where n = number of unpaired electrons.

Number of unpaired electrons in Cr^{2+} ($[Ar]\ 3d^4$) is 4, in Co^{2+} ($[Ar]\ 3d^7$) is 3, in Fe^{2+} ($[Ar]\ 3d^6$) is 4, in Mn^{2+} ($[Ar]\ 3d^5$) is 5.

As the number of unpaired electrons in Cr^{2+} and Fe^{2+} are same, hence $[Cr(H_2O)_6]^{2+}$ and $[Fe(H_2O)_6]^{2+}$ will have same magnetic moment.

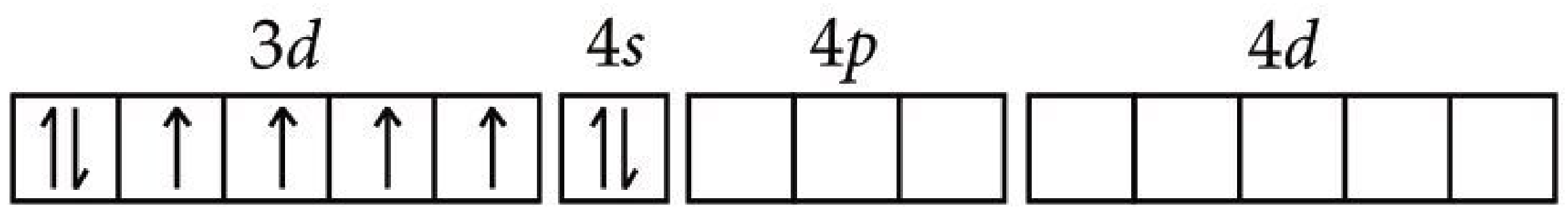
23. (b)

24. (b): $[RhCl(PPh_3)_3]$, chlorido*tris*(triphenylphosphine rhodium(I)), is known as Wilkinson's catalyst. It is used as a homogeneous hydrogenation of alkenes.

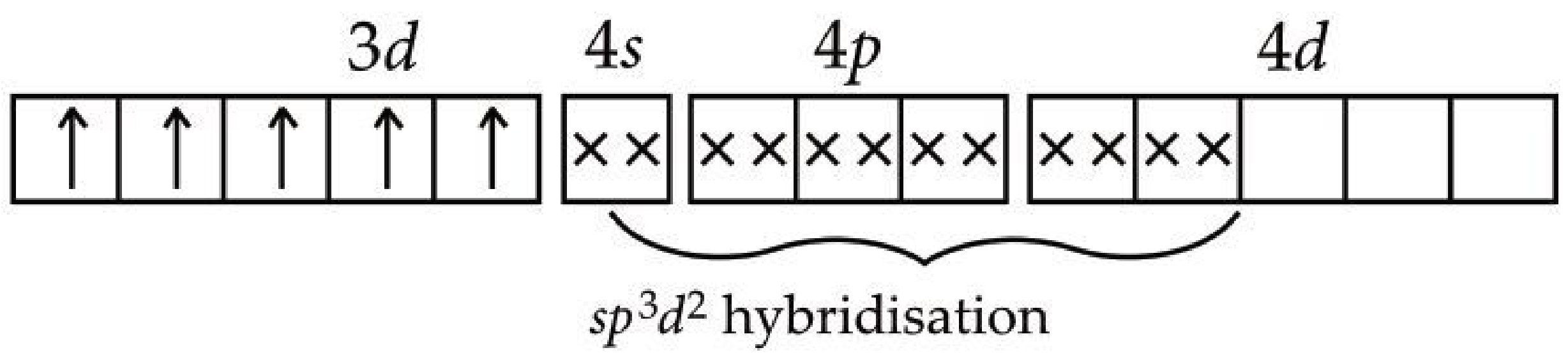
25. (d): The overlap of a lone pair on the C atom with the empty hybrid metal orbital forms a carbon-to-metal σ–bond. The transition metal atom in a metal carbonyl has filled non-bonding *d*-orbitals which are of proper symmetry to overlap with the antibonding orbitals of CO. The electronic charge is transferred from the filled non-bonding orbitals of the metals to π* orbitals of the ligand CO. This reduces the bond order of CO. The π back-bonding strengthens the M – C bond order, it weakens the C – O bond order.

26. (d): $[Co(NH_3)_4Cl_2]NO_2$ and $[Co(NH_3)_4Cl(NO_2)]Cl$ are ionization isomers.

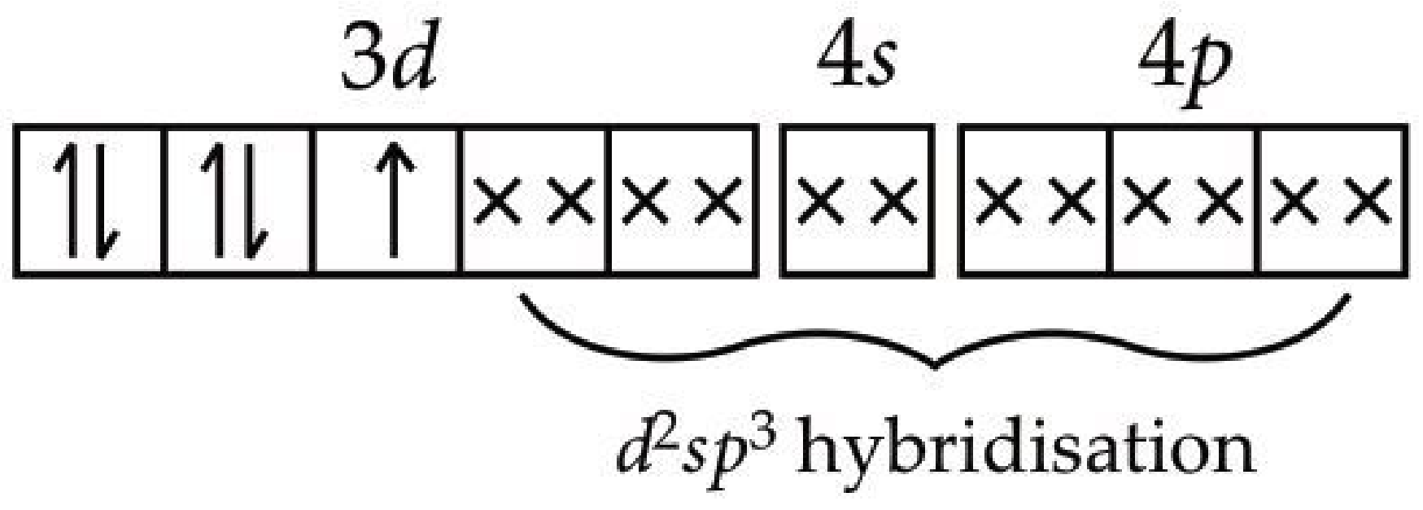
27. (c) : Fe(26) : $3d^6 4s^2$



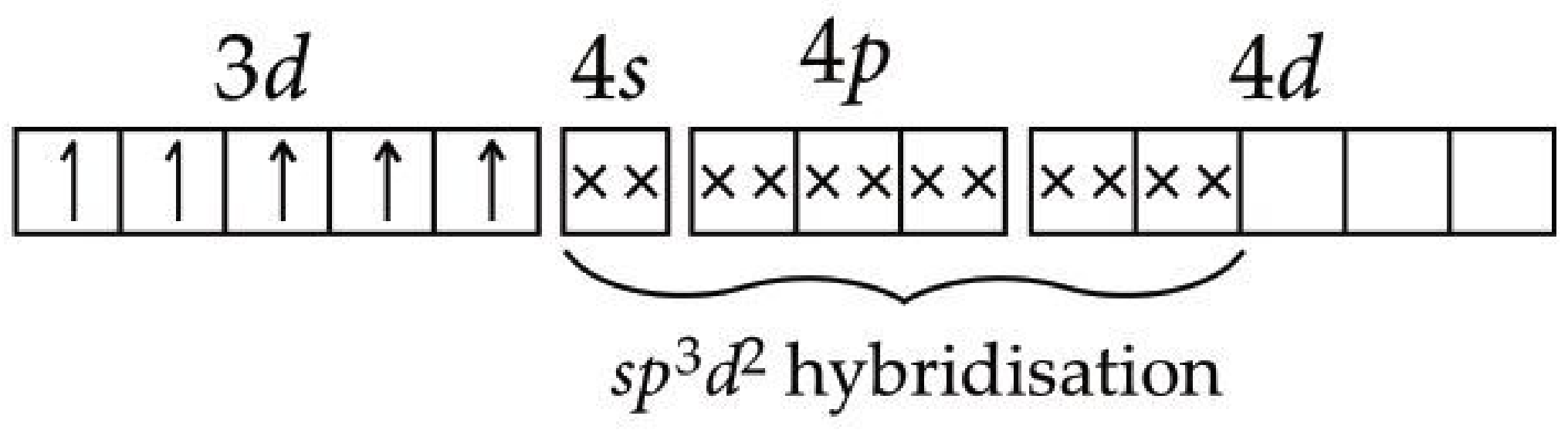
$[Fe(H_2O)_6]^{3+}$: As H_2O is a weak field ligand, pairing of electrons does not take place.



$[Fe(CN)_6]^{3-}$: As CN^- is a strong field ligand, pairing of electrons takes place.

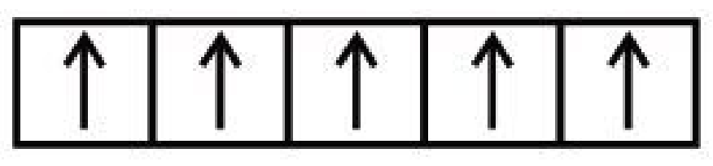


$[FeCl_6]^{3-}$: As Cl^- is a weak field ligand, pairing of electrons does not take place.



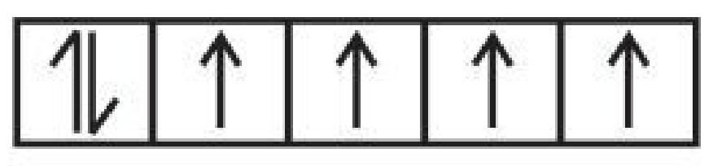
28. (b)

29. (b) : Oxidation number of Mn in $[Mn(H_2O)_6]^{2+} = +2$

Mn^{2+} ($Z = 25$) $3d^5$: 

A weak field ligand does not force electrons to pair up hence number of unpaired electrons in the compound will remain five.

30. (c) : In $[CoF_6]^{3-}$, oxidation state of Co = +3

$Co^{3+} \longrightarrow 3d^6$ *i.e.*, 

F^- is a weak field ligand, hence no pairing takes place thus number of unpaired electrons = 4

31. (c) : Colour of transition metal complexes is explained by *d-d* transition.

32. (a) : F^- being weak field ligand results in high spin complex.

33. (b): Oxidation state of Cr in $[Cr(H_2O)_6]^{3+} = +3$

Cr^{3+} ($Z = 24$) $\longrightarrow 3d^3$ *i.e.*, 3 unpaired electrons.

Oxidation state of Fe in $[Fe(H_2O)_6]^{2+} = +2$

Fe^{2+} ($Z = 26$) $\longrightarrow 3d^6$ *i.e.*, 4 unpaired electrons.

Oxidation state of Cu in $[Cu(H_2O)_6]^{2+} = +2$

Cu^{2+} ($Z = 29$) $\longrightarrow 3d^9$ *i.e.*, 1 unpaired electron.

Oxidation state of Zn in $[Zn(H_2O)_6]^{2+} = +2$

Zn^{2+} ($Z = 30$) $\longrightarrow 3d^{10}$ *i.e.*, no unpaired electron.

Greater the number of unpaired electrons, higher will be the paramagnetism. Hence, $[Fe(H_2O)_6]^{2+}$ with maximum number (4) of unpaired electrons show highest degree of paramagnetism.

34. (c) : A species is coloured when it contains unpaired *d*-electrons which are capable of undergoing *d-d* transition on adsorption of light of a particular wavelength.

In TiF_6^{2-}, $Ti^{4+}: 3d^0$, colourless
In CoF_6^{3-}, $Co^{3+}: 3d^6$, coloured
In Cu_2Cl_2, $Cu^+: 3d^{10}$, colourless
In $NiCl_4^{2-}$, $Ni^{2+}: 3d^8$, coloured

35. (a)

36. (c) : Tetrahedral complexes do not show geometrical isomerism because the relative position of the atoms with respect to each other will be the same.

37. (a) : Δ_t is smaller as compared to Δ_o. Consequently the orbital splitting energies are not sufficiently large for forcing the pairing. Therefore, low spin configurations are rarely observed.

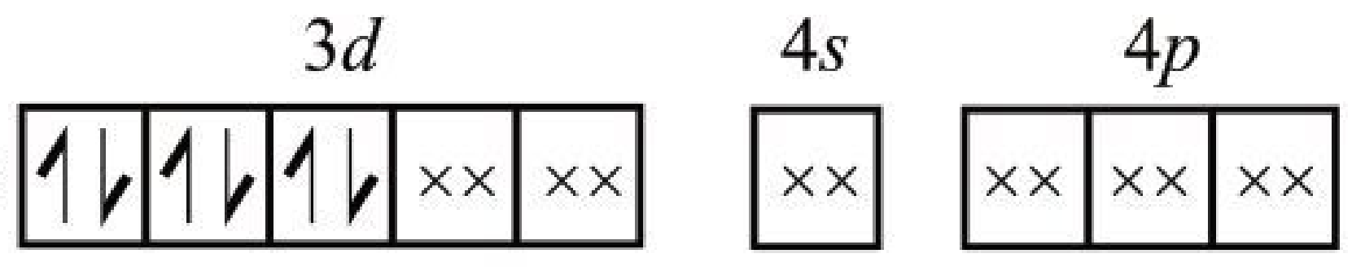
38. (a) : As inner d-orbital is involved in hybridisation, pairing of electrons occur and hence due to less or no unpaired electrons the complexes are low spin complexes.

39. (a) **40. (c)**

41. (b): Order of ability to cause splitting of d-orbitals
$F^- < OH^- < C_2O_4^{2-} < O^{2-} < H_2O < NCS^- < NH_3 < en$
CFSE ∝ Oxidation state
Hence CFSE order :

$$\underset{B}{[Co(H_2O)_6]^{2+}} < \underset{A}{[CoF_6]^{3-}} < \underset{C}{[Co(NH_3)_6]^{3+}} < \underset{D}{[Co(en)_3]^{3+}}$$

42. (a) : $[Co(C_2O_4)_3]^{3-}$:



43. (d): The magnitude of Δ_o follows the order :
$Cl^- < H_2O < NH_3 < CN^-$

44. (d): $\Delta_t = \frac{4}{9}\Delta_o = \frac{4}{9} \times 18000 = 8000\ cm^{-1}$

45. (a) : In low spin state, the electrons get paired up.
$d^4 : t_{2g}^4\, e_g^0$

46. (d): It involves sp^3d^2 hybridisation and not d^2sp^3.

47. (c)

48. (d): $[Co(NH_3)_6]^{3+}$ is d^2sp^3 hybridised with all electrons paired hence, it is diamagnetic and inner orbital complex.

49. (b)

50. (c) : Inner orbital complexes are formed with strong ligands as they force electrons to pair up and hence the complex will be either diamagnetic or will have less number of unpaired electrons.

◆◆

UNSCRAMBLE ME

Unscramble the words given in column I and match them with their explanations in column II.

Column I	Column II
1. AGMENTETI	(a) Having the same lattice type and crystal structure.
2. SRTUISOCRALTU	(b) Constituent of nucleic acids.
3. ETANOMERM	(c) Process which involves both the catalytic cracking and hydrogenation of petroleum fractions, yielding high quality gasolines.
4. UANGEIN	(d) The mineral form of black Fe_3O_4 with the spinel structure that is used as an iron ore, a flux and a pigment for glazes.
5. KACDROHYRCGIN	(e) An instrument used to measure the pressure of a fluid by comparing it with a pre-determined column of a standard fluid.
6. NETIONAPYOTR	(f) An aliphatic alcohol regarded as derived from an alkane.
7. OLDIFEIN	(g) The reversible transformation of one form or an allotrope into another at a definite transition temperature.
8. UMECNE	(h) Obtained commercially by the reaction of benzene with propene in the presence of a catalyst such as hydrogen fluoride.
9. ANOKALL	(i) Organic compounds containing an $>SO_2$ group linked directly to two carbon atoms.
10. ULPHSNOES	(j) A hydrocarbon containing two double bonds, usually among carbon atoms.

Readers can send their responses at editor@mtg.in or post us with complete address by 10th of every month. Winners' names and answers will be published in next issue.

Are you ready for Olympiads?

LEVEL 2

Exam on 12th February 2023

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CLASS XI

SYLLABUS*

Section – 1 : *Physics* : Units and Measurements, Mechanics, Properties of Matter, Heat and Thermodynamics, Oscillations, Waves.

Chemistry : Some Basic Concepts of Chemistry, Structure of Atom, Classification of Elements and Periodicity in Properties, Chemical Bonding and Molecular Structure, Thermodynamics, Equilibrium, Redox Reactions, Organic Chemistry - Some Basic Principles and Techniques, Hydrocarbons.

Section – 2 : Higher Order Thinking Questions - Syllabus as per Section – 1.

Total Questions : 50 Time : 1 hr.

PATTERN & MARKING SCHEME

Section	(1) Physics & Chemistry	(2) Achievers Section	(3) Mathematics or Biology
No. of Questions	25	5	20
Marks per Ques.	1	3	1

Section – 3 : Sets, Relations and Functions, Principle of Mathematical Induction, Logarithms, Complex Numbers & Quadratic Equations, Linear Inequations, Sequences and Series, Trigonometry, Straight Lines, Conic Sections, Permutations and Combinations, Binomial Theorem, Statistics, Mathematical Reasoning, Limits and Derivatives, Probability, Introduction to 3-D Geometry.

OR

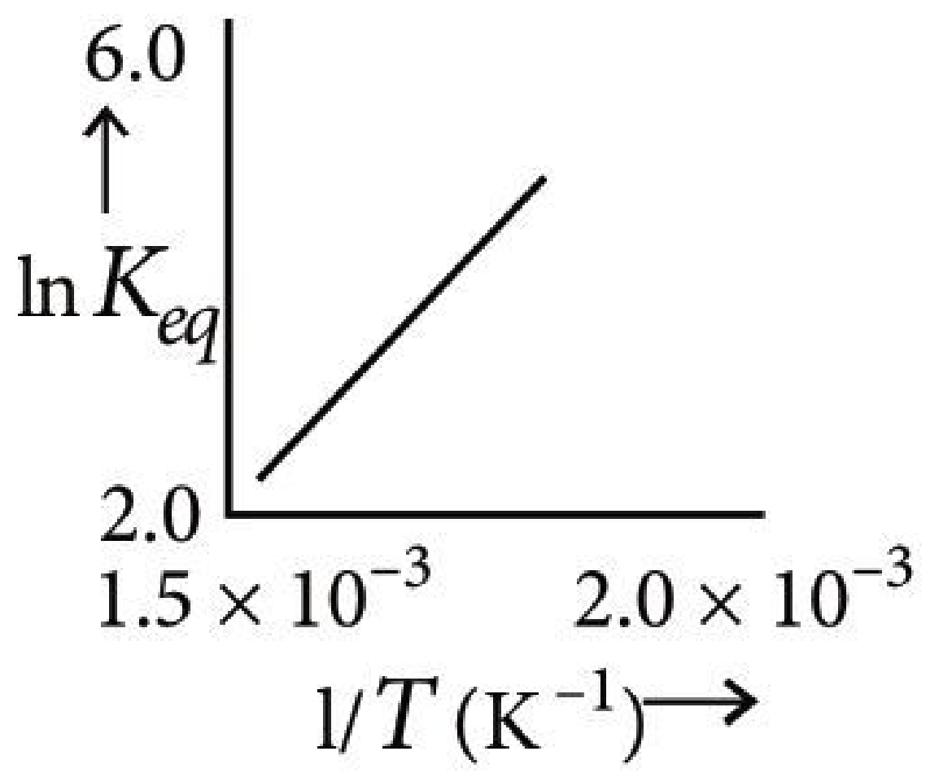
Section – 3 : Diversity in the Living World, Structural Organisation in Plants and Animals, Cell : Structure and Functions, Plant Physiology, Human Physiology.

Practice Questions

1. Arrange the carbanions, $(CH_3)_3\bar{C}$, $\bar{C}Cl_3$, $(CH_3)_2\bar{C}H$, $C_6H_5\bar{C}H_2$, in order of their decreasing stability.

A. $C_6H_5\bar{C}H_2 > \bar{C}Cl_3 > (CH_3)_3\bar{C} > (CH_3)_2\bar{C}H$
B. $(CH_3)_2\bar{C}H > \bar{C}Cl_3 > C_6H_5\bar{C}H_2 > (CH_3)_3\bar{C}$
C. $\bar{C}Cl_3 > C_6H_5\bar{C}H_2 > (CH_3)_2\bar{C}H > (CH_3)_3\bar{C}$
D. $(CH_3)_3\bar{C} > (CH_3)_2\bar{C}H > C_6H_5\bar{C}H_2 > \bar{C}Cl_3$

2. A schematic plot of ln K_{eq} *versus* inverse of temperature for a reaction is shown in the figure. The reaction must be



A. exothermic
B. endothermic
C. one with negligible enthalpy change
D. highly spontaneous at ordinary temperature.

3. At equilibrium, $N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$ the observed molecular weight of N_2O_4 is 80 g mol^{-1} at 350 K. The percentage dissociation of $N_2O_{4(g)}$ at 350 K is

A. 10% B. 15% C. 20% D. 18%

4.

Bond	Bond enthalpy
N≡N	945 kJ mol^{-1}
H—H	436 kJ mol^{-1}
N—H	391 kJ mol^{-1}

Calculate the enthalpy change of the reaction,

$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$

A. –89 kJ mol^{-1} B. –93 kJ mol^{-1}
C. –105 kJ mol^{-1} D. 105 kJ mol^{-1}

5. Match the column-I with column-II and choose the correct option.

	Column-I (Element/elements)		Column-II (Group number)
(I)	An element whose fourth shell contains two *p*-electrons	(p)	8th group
(II)	An element whose valence shell contains one unpaired *p*-electron	(q)	12th group
(III)	An element which receives last electron in (*n* – 1) *d*-subshell	(r)	14th group
(IV)	An element with the ground state electronic configuration $[Ar]4s^23d^{10}$	(s)	17th group

	(I)	(II)	(III)	(IV)
A.	p	q, r	s	q
B.	r	p, q	q	s
C.	r	s	p, q	q
D.	q	p	p, s	r

*For latest updates visit www.sofworld.org

6. 2 mol of an ideal gas at 27°C is expanded reversibly from 2 L to 20 L. Find entropy change (R = 2 cal/mol K).

A. 92.1 B. 0 C. 4 D. 9.2

7. The hyperconjugative stabilities of *tert*-butyl cation and 2-butene, respectively, are due to

A. $\sigma \rightarrow p$ (empty) and $\sigma \rightarrow \pi^*$ electron delocalisation

B. $\sigma \rightarrow \sigma^*$ and $\sigma \rightarrow \pi$ electron delocalisations

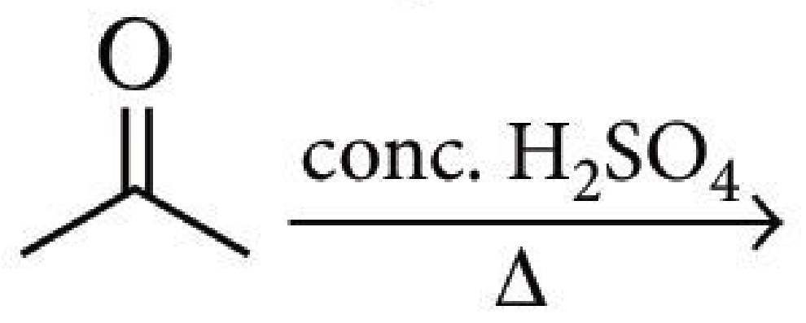
C. $\sigma \rightarrow p$ (filled) and $\sigma \rightarrow \pi$ electron delocalisations

D. p (filled) $\rightarrow \sigma^*$ and $\sigma \rightarrow \pi^*$ electron delocalisations.

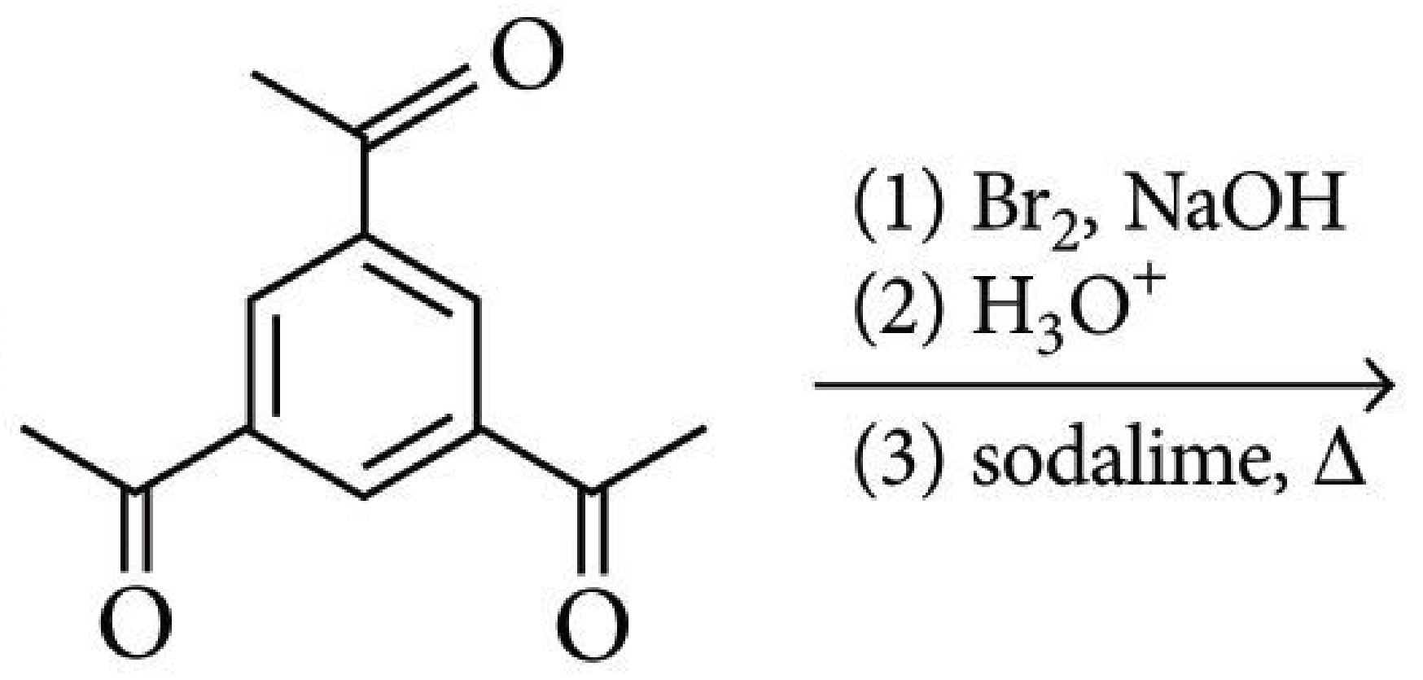
8. Balance the reaction,
$X\text{Zn} + \text{NO}_3^- + Y\text{H}^+ \rightarrow X\text{Zn}^{2+} + \text{NH}_4^+ + Z\text{H}_2\text{O}$ and write the value of X, Y and Z.

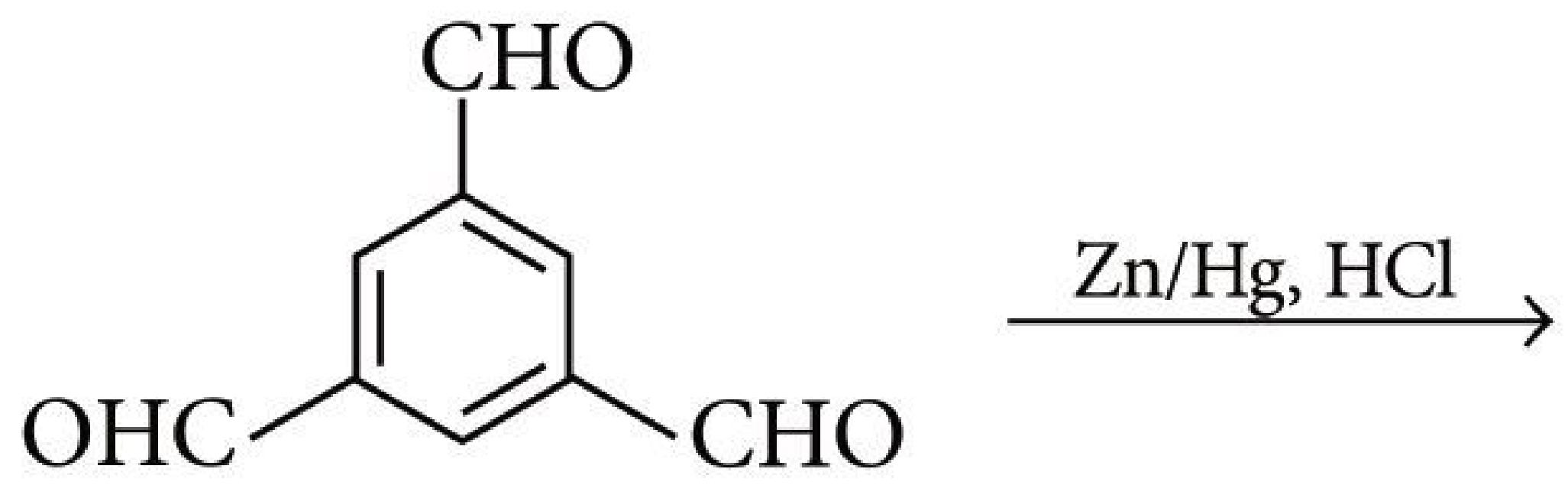
A. 4, 10, 3 B. 3, 8, 3
C. 3, 10, 3 D. 4, 3, 10

9. The reaction(s) leading to the formation of 1,3,5-trimethylbenzene is (are)

(i)


(ii) $\text{Me}-\!\!\equiv\!\!-\text{H} \xrightarrow[873\ \text{K}]{\text{heated iron tube}}$

(iii)


(iv)


A. i and ii only B. ii only
C. i, ii and iv only D. i, iii and iv only

10. The standard reduction potentials of Mg, Zn, Ni, H_2, Cu and Ag are –2.37, – 0.76, – 0.25, 0.00, 0.34 and 0.80 volt respectively. Which one of the following cells has maximum voltage?

A. $\text{Mg} + 2\text{Ag}^+ \rightarrow \text{Mg}^{2+} + 2\text{Ag}$

B. $\text{Cu}^{2+} + \text{H}_2 \rightarrow \text{Cu} + 2\text{H}^+$

C. $\text{Ni} + \text{Cu}^{2+} \rightarrow \text{Ni}^{2+} + \text{Cu}$

D. $\text{Zn} + 2\text{Ag}^+ \rightarrow \text{Zn}^{2+} + 2\text{Ag}$

11. Among the following species, identify the isostructural pairs

$\text{NF}_3, \text{NO}_3^-, \text{BF}_3, \text{H}_3\text{O}^+, \text{HN}_3$

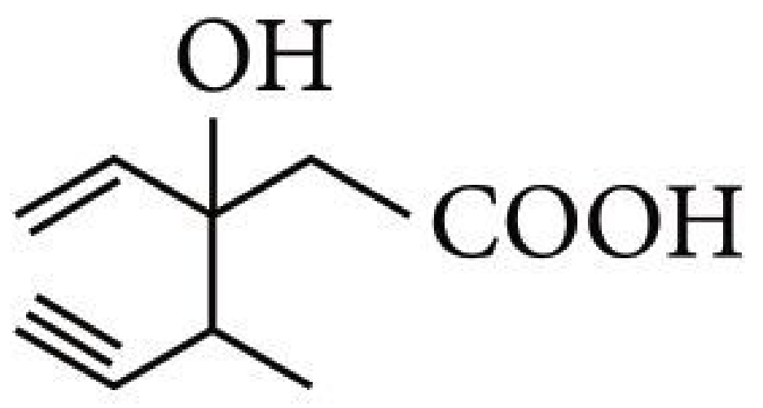
A. $[\text{NF}_3, \text{NO}_3^-]$ and $[\text{BF}_3, \text{H}_3\text{O}^+]$

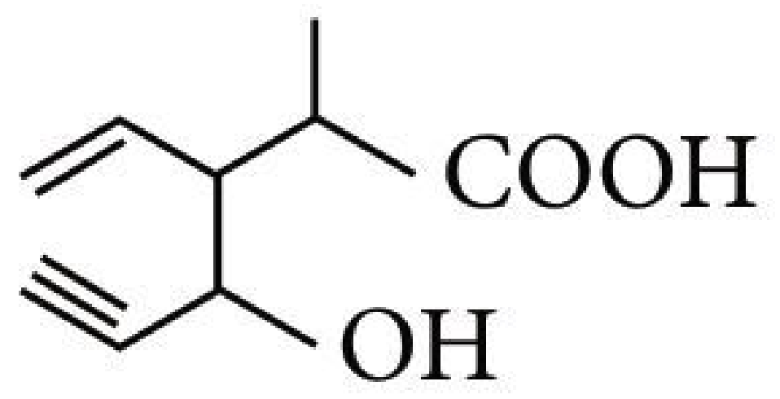
B. $[\text{NF}_3, \text{HN}_3]$ and $[\text{NO}_3^-, \text{BF}_3]$

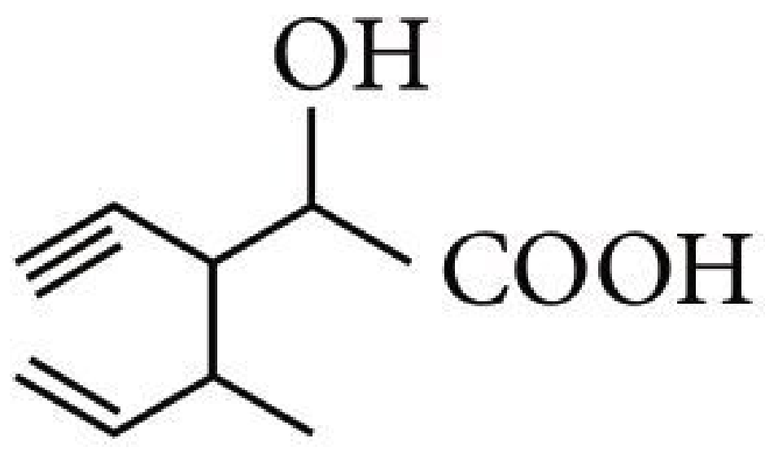
C. $[\text{NF}_3, \text{H}_3\text{O}^+]$ and $[\text{NO}_3^-, \text{BF}_3]$

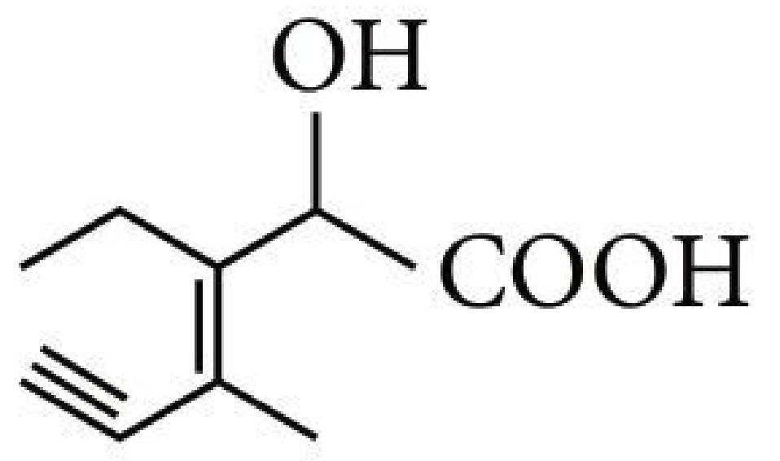
D. $[\text{NF}_3, \text{H}_3\text{O}^+]$ and $[\text{HN}_3, \text{BF}_3]$

12. Structure of the compound whose IUPAC name is 3-Ethyl-2-hydroxy-4-methylhex-3-en-5-ynoic acid is

A.


B.


C.


D.


13. The correct statement regarding electrophile is

A. electrophile is a negatively charged species and can form a bond by accepting a pair of electrons from another electrophile

B. electrophiles are generally neutral species and can form a bond by accepting a pair of electrons from a nucleophile

C. electrophile can be either neutral or positively charged species and can form a bond by accepting a pair of electrons from a nucleophile

D. electrophile is a negatively charged species and can form a bond by accepting a pair of electrons from a nucleophile.

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14. The value of $\Delta G°$ for phosphorylation of glucose in glycolysis is 13.8 kJ/mol. The value of K_c at 298 K is

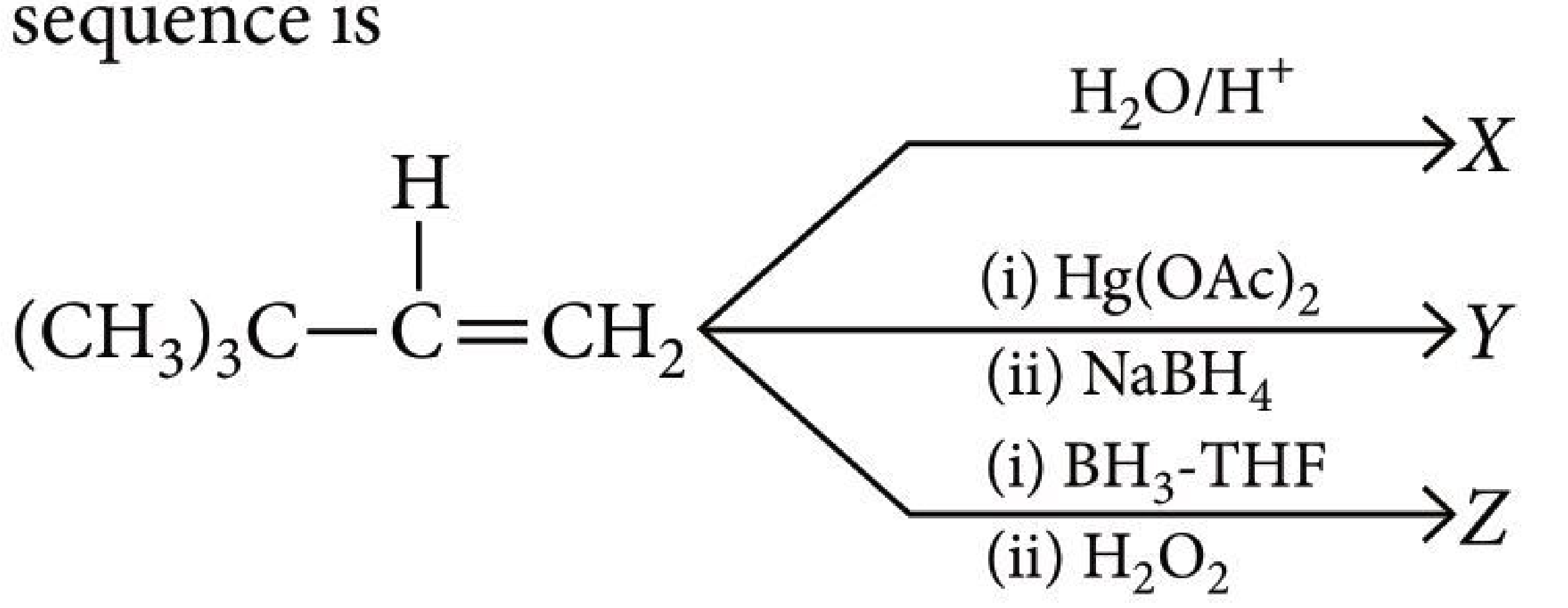
A. $e^{-5.569}$
B. 3.81×10^{-3}
C. 2.65×10^{-2}
D. both A and B.

15. Select the one having the smallest bond angle among the following.

A. CH_4
B. SiH_4
C. NH_3
D. H_2O

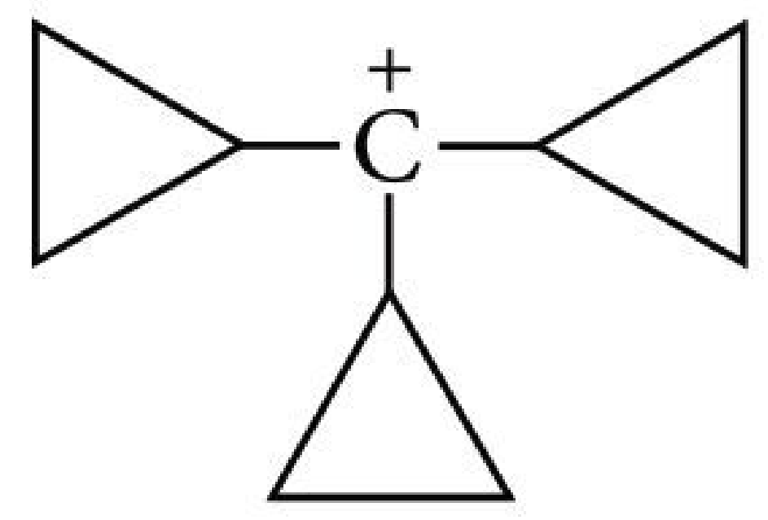
ACHIEVERS SECTION

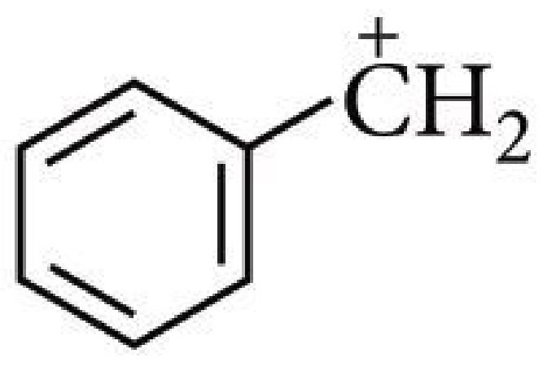
16. The correct statement about the following reaction sequence is

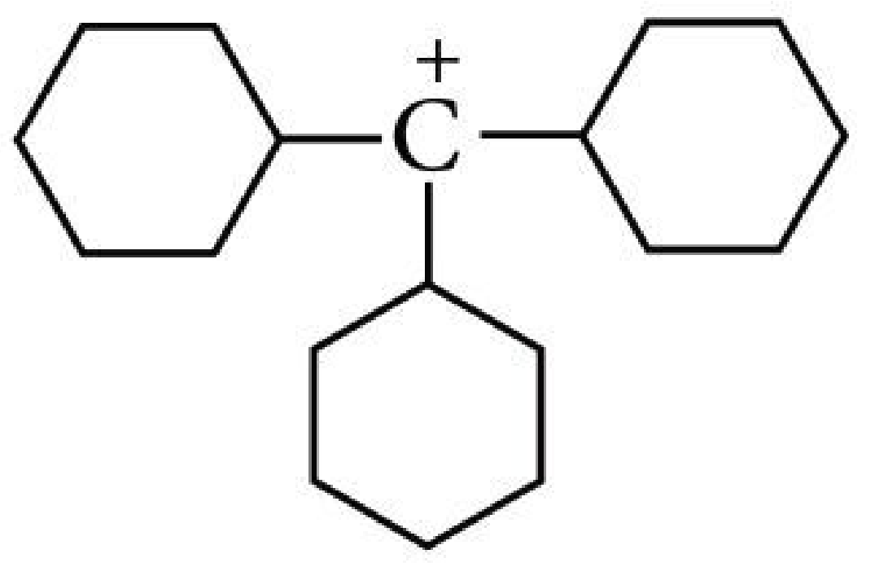


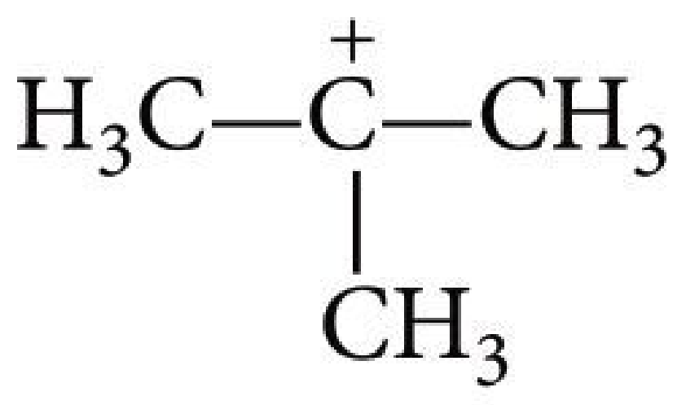
A. *X* and *Y* are optically active whereas *Z* is optically inactive.
B. *Y* and *Z* are optically active whereas *X* is optically inactive.
C. *X* and *Z* are optically inactive whereas *Y* is optically active.
D. *Y* and *Z* are optically inactive whereas *X* is optically active.

17. Which one among the following carbocations has the longest half-life?

A.


B.


C.


D.

$H_3C-\overset{+}{\underset{CH_3}{C}}-CH_3$

18. The following process has been used to obtain iodine :

$NaI + AgNO_3 \longrightarrow AgI + NaNO_3$

$2AgI + Fe \longrightarrow FeI_2 + 2Ag$

$2FeI_2 + 3Cl_2 \longrightarrow 2FeCl_3 + 2I_2$

How many grams of $AgNO_3$ are required in the first step for every 254 kg I_2 produced in the third step?

A. 340 kg
B. 85 kg
C. 68 kg
D. 380 kg

19. The correct order of increasing C — O bond length is shown in

A. $CO < CO_2 < CO_3^{2-}$
B. $CO_3^{2-} > CO_2 > CO$
C. $CO_2 < CO_3^{2-} < CO$
D. $CO_2 > CO > CO_3^{2-}$

20. Select the correct statement.

A. The order of Xe–F bond length in various fluorides of xenon is $XeF_2 < XeF_4 < XeF_6$.
B. PH_5 can undergo sp^3d hybridisation to have octahedral geometry.
C. Dipole moment of CH_3F is greater than that of CH_3Cl.
D. Increasing strength of hydrogen bonding is Cl–H----Cl < N–H----N < O–H----O < F–H----F

Darken your choice with HB Pencil

1.	Ⓐ Ⓑ Ⓒ Ⓓ	5.	Ⓐ Ⓑ Ⓒ Ⓓ	9.	Ⓐ Ⓑ Ⓒ Ⓓ	13.	Ⓐ Ⓑ Ⓒ Ⓓ	17.	Ⓐ Ⓑ Ⓒ Ⓓ
2.	Ⓐ Ⓑ Ⓒ Ⓓ	6.	Ⓐ Ⓑ Ⓒ Ⓓ	10.	Ⓐ Ⓑ Ⓒ Ⓓ	14.	Ⓐ Ⓑ Ⓒ Ⓓ	18.	Ⓐ Ⓑ Ⓒ Ⓓ
3.	Ⓐ Ⓑ Ⓒ Ⓓ	7.	Ⓐ Ⓑ Ⓒ Ⓓ	11.	Ⓐ Ⓑ Ⓒ Ⓓ	15.	Ⓐ Ⓑ Ⓒ Ⓓ	19.	Ⓐ Ⓑ Ⓒ Ⓓ
4.	Ⓐ Ⓑ Ⓒ Ⓓ	8.	Ⓐ Ⓑ Ⓒ Ⓓ	12.	Ⓐ Ⓑ Ⓒ Ⓓ	16.	Ⓐ Ⓑ Ⓒ Ⓓ	20.	Ⓐ Ⓑ Ⓒ Ⓓ

SOLUTIONS

1. **(C)**

2. **(A) :** $\ln\frac{K_2}{K_1} = \frac{\Delta H}{R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$

$$\ln\frac{6}{2} = \frac{\Delta H}{R}[1.5\times10^{-3} - 2\times10^{-3}]$$

$$\Rightarrow \quad \ln 3 = \frac{\Delta H}{R}\times(-0.5\times10^{-3})$$

ΔH of reaction comes out to be negative. Hence, reaction is exothermic.

3. **(B) :** $N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$

$t = 0$	1	0
$t = t_{eq}$	$1 - \alpha$	2α

Molecular mass = 92 g mol^{-1}

Given molecular mass = 80 g mol^{-1}

$$i = \frac{\text{Abnormal molecular mass}}{\text{Normal molecular mass}} = \frac{92}{80} \quad \ldots\text{(i)}$$

$$i = \frac{1-\alpha+2\alpha}{1} = 1+\alpha \quad \ldots\text{(ii)}$$

On comparing equations (i) & (ii), we get

$$1+\alpha = \frac{92}{80} \Rightarrow \alpha = 0.15$$

Percentage dissociation = 0.15 × 100 = 15%

4. (B)

5. (C)

6. (D) : Applying, $\Delta S = \frac{q_{rev}}{T}$

But $q_{rev} = -W_{rev} = 2.303\,nRT\log\frac{V_2}{V_1}$

$n = 2$, $R = 2$ cal/ mol K, $T = 27°C = (27 + 273)\ K = 300\ K$

$V_2 = 20$ L, $V_1 = 2$ L,

$q_{rev} = 2.303 \times nRT \log 10 = 2.303\ nRT$

$$\Delta S = \frac{2.303\,nRT}{T} = 2.303 \times 2 \times 2 = 9.2\,\text{cal K}^{-1}\ \text{mol}^{-1}$$

7. (A)

8. (A) : $4Zn + NO_3^- + 10H^+ \rightarrow 4Zn^{2+} + NH_4^+ + 3H_2O$

9. (C) **10. (A)**

11. (C) : Isostructural compounds have same type of hybridisation.

In NF_3, N is sp^3 hybridised (3 *b.p.* + 1 *l.p.*)

In NO_3^-; N is sp^2 hybridised.

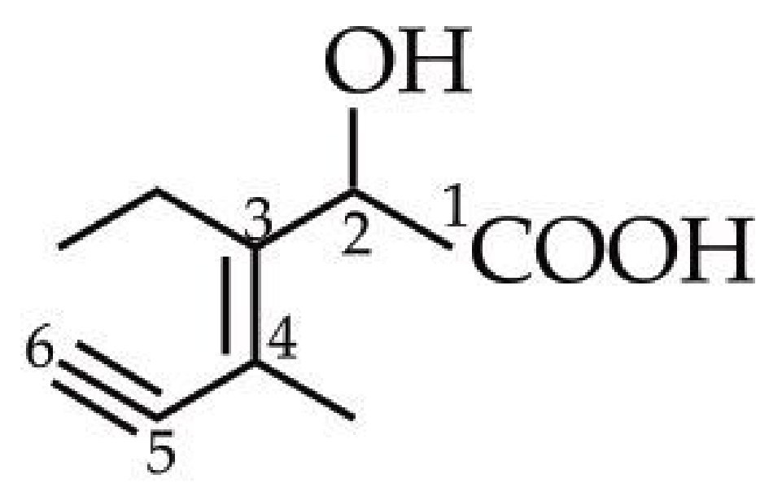
In BF_3; B is sp^2 hybridised.

In H_3O^+; O is sp^3 hybridised.

In HN_3; central nitrogen is *sp* hybridised.

From this we find that NF_3 and H_3O^+ are isostructural and BF_3 and NO_3^- are isostructural.

12. (D) :



IUPAC name of the structure is 3-Ethyl-2-hydroxy-4-methylhex-3-en-5-ynoic acid.

13. (C)

14. (D) : $\Delta G° = -RT \ln K_c$

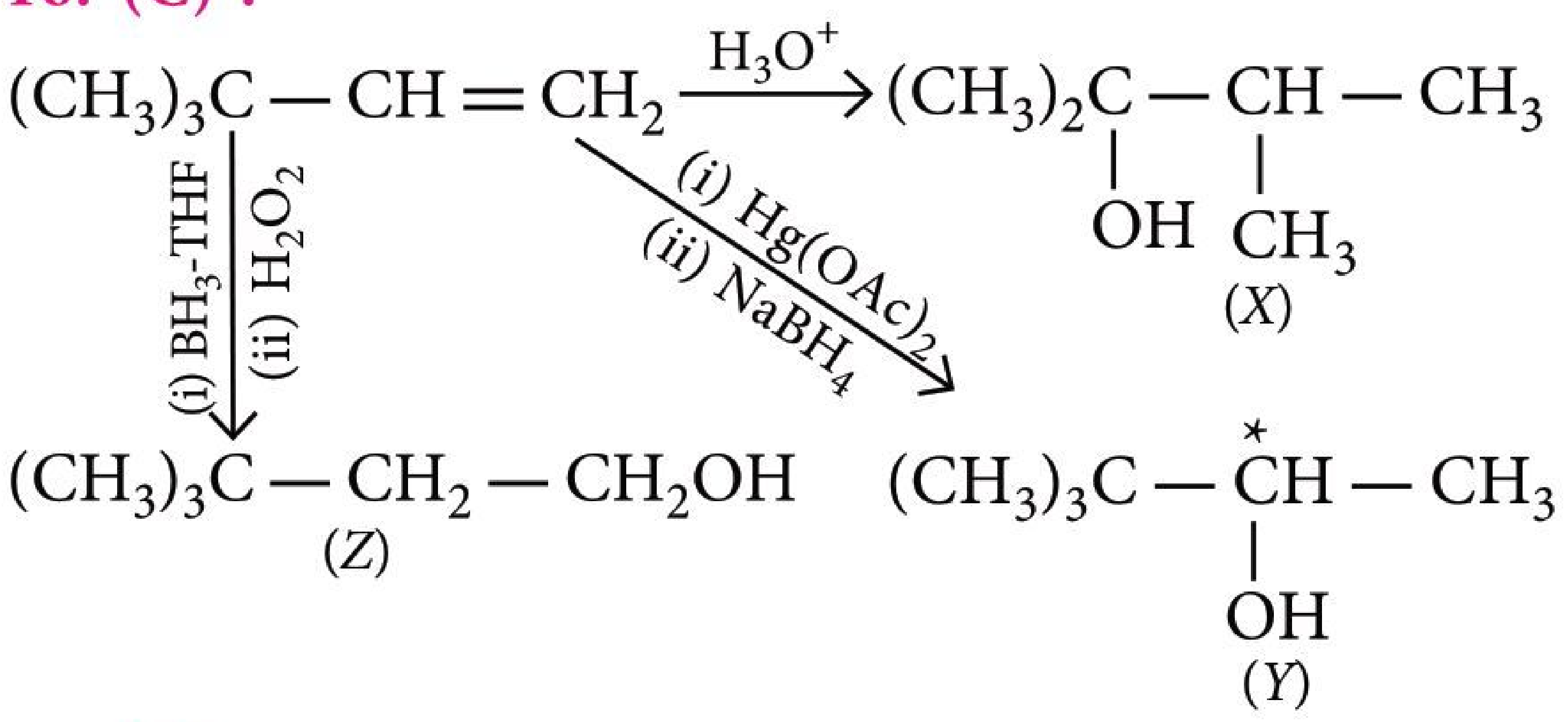
$$K_c = e^{-\Delta G°/RT} = e^{-\frac{13.8\times1000}{298\times8.314}} = e^{-5.569}$$

or $K_c = 3.81 \times 10^{-3}$

15. (D) : $CH_4 \rightarrow 109° 28'$; $SiH_4 \rightarrow 109° 28'$

$NH_3 \rightarrow 107°$; $H_2O \rightarrow 104° 30'$

16. (C) :



17. (A) : Tricyclomethyl cation has longest half life due to it's stability by bent orbitals.

18. (A) : Balanced equations are :

$NaI + AgNO_3 \longrightarrow AgI + NaNO_3$

$2AgI + Fe \longrightarrow FeI_2 + 2Ag$

$2FeI_2 + 3Cl_2 \longrightarrow 2FeCl_3 + 2I_2$

$\therefore$ Mole of I_2 = Mole of FeI_2

$$= \left(\frac{\text{Mole of AgI}}{2}\right) = \left(\frac{\text{Mole of AgNO}_3}{2}\right)$$

$$\frac{254\times10^3}{254} = \frac{\text{Mole of AgNO}_3}{2}$$

$\Rightarrow\ 2 \times 10^3$ = Mole of $AgNO_3$

$$2 \times 10^3 = \frac{\text{Mass of AgNO}_3}{\text{Molar mass of AgNO}_3}$$

$\therefore$ Mass of $AgNO_3 = 170 \times (2 \times 10^3)$g = 340 kg

19. (A) **20. (D)**

For other sections/subjects please refer to Physics For You and Biology Today

◆ ◆

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Are you ready for Olympiads?

LEVEL 2

Exam on 12th February 2023

SCIENCE OLYMPIAD FOUNDATION

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CLASS XII

SYLLABUS*

Section – 1 : *Physics* : Electricity and Magnetism, Electromagnetic Induction, Alternating current, Electromagnetic waves, Optics, Modern Physics, Semiconductor Electronics, Communication Systems.

Chemistry : Solid State, Solutions, Electrochemistry, Chemical Kinetics, Surface Chemistry, General Principles and Processes of Isolation of Elements, *p*-Block Elements (Group 15 to 18), *d*- & *f*-Block Elements, Coordination Compounds, Haloalkanes and Haloarenes, Alcohols, Phenols and Ethers, Aldehydes, Ketones and Carboxylic Acids, Amines, Biomolecules, Polymers, Chemistry in Everyday Life.

Section – 2 : Higher Order Thinking Questions - Syllabus as per Section – 1.

Section – 3 : Relations and Functions, Inverse Trigonometric Functions, Matrices and Determinants, Continuity and Differentiability, Application of Derivatives, Integrals, Application of Integrals, Differential Equations, Vector Algebra, Three Dimensional Geometry, Probability, Linear Programming.

OR

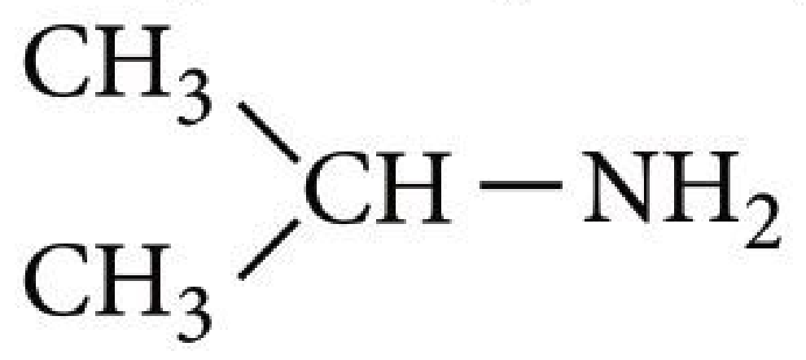
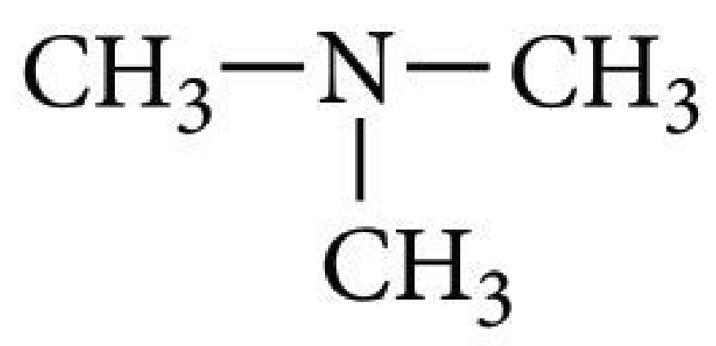
Section – 3 : Reproduction, Genetics and Evolution, Biology in Human Welfare, Biotechnology, Ecology.

Total Questions : 50 Time : 1 hr.

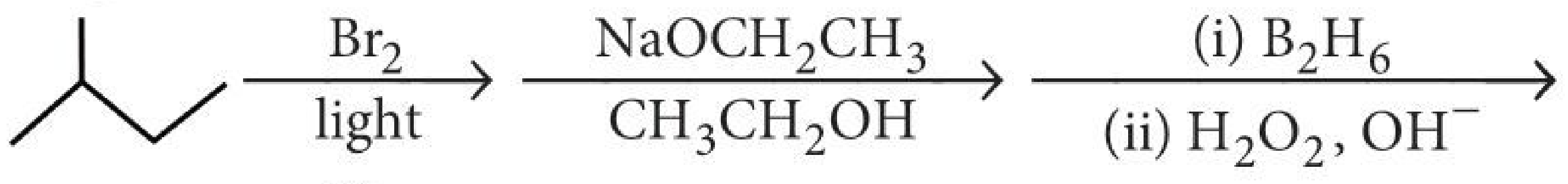
PATTERN & MARKING SCHEME

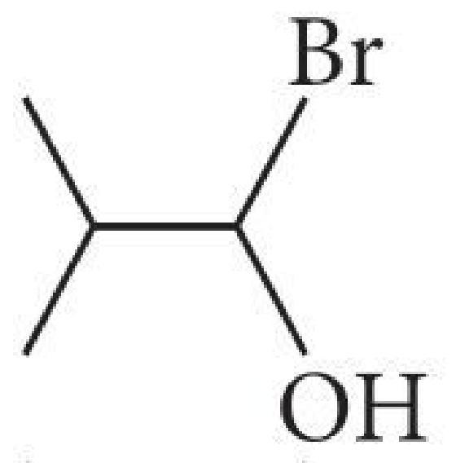
Section	(1) Physics & Chemistry	(2) Achievers Section	(3) Mathematics or Biology
No. of Questions	25	5	20
Marks per Ques.	1	3	1

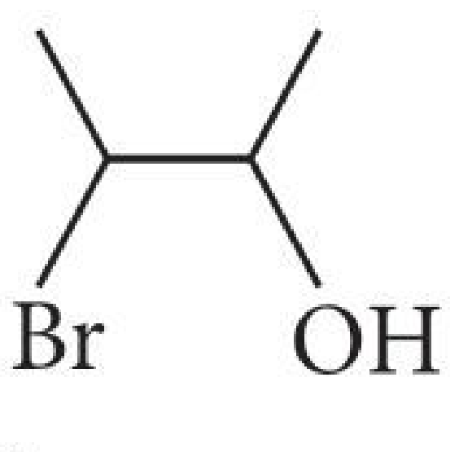
Practice Questions

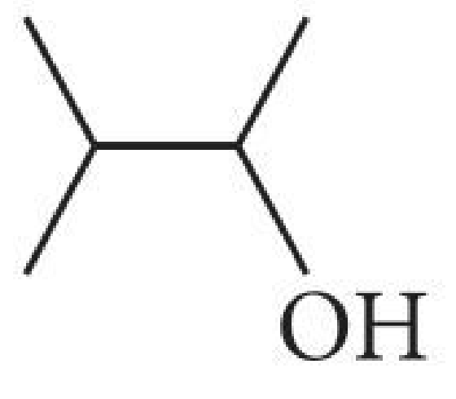
1. An organic compound $C_3H_9N(A)$ when treated with nitrous acid gave an alcohol and N_2 gas was evolved. (A) on warming with $CHCl_3$ and caustic potash gave (B) which on reduction gave isopropyl methyl amine. Predict the structure of (A).
   A. $CH_3-CH_2-CH_2-NH_2$
   B. 
   $(CH_3)_2CH-NH_2$
   C. $CH_3-CH_2-NH-CH_3$
   D. 
   $CH_3-N(CH_3)-CH_3$

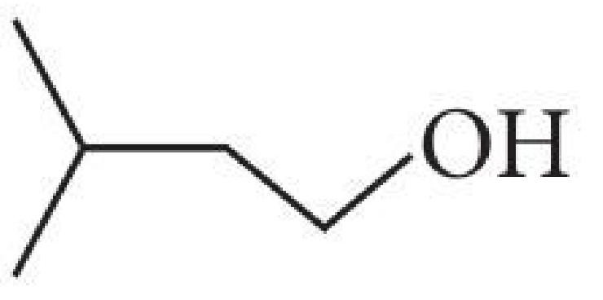
2. Major organic product formed from the following sequence of reactions is



   A. 

   B. 

   C. 

   D. 

3. Consider the reaction, $2A + B \rightarrow$ products. When concentration of B alone was doubled, the half-life did not change. When the concentration of A alone was doubled, the rate increased by two times. The unit of rate constant for this reaction is
   A. s^{-1}
   B. $L\ mol^{-1}\ s^{-1}$
   C. $mol\ L^{-1}\ s^{-1}$
   D. none of these.

4. If 90 g of water is electrolysed completely with 50% current efficiency
   A. 10 Faraday of electricity will be consumed
   B. 20 Faraday of electricity will be consumed
   C. 188 L (STP) of gases will be produced
   D. 84 L (STP) of gases will be produced.

5. A solution weighing '*a*' g has molality '*b*'. The molecular mass of solute, if the mass of solute is '*c*' g, will be
   A. $\frac{c}{b}\times\frac{1000}{(a-c)}$
   B. $\frac{b}{a}\times\frac{1000}{(a-b)}$
   C. $\frac{b}{c}\times\frac{1000}{(a-c)}$
   D. $\frac{c}{a}\times\frac{1000}{(b-a)}$

6. $FeCr_2O_4 \xrightarrow{I} Na_2CrO_4 \xrightarrow{II} Cr_2O_3 \xrightarrow{III} Cr$
   I, II and III are

	I	II	III
A.	Na_2CO_3/air, Δ	NH_4Cl, Δ	Al
B.	NaOH/air, Δ	C, heat	C, heat
C.	Na_2CO_3/air, Δ	C, heat	C, heat
D.	NaOH/air, heat	Al, heat	C, heat

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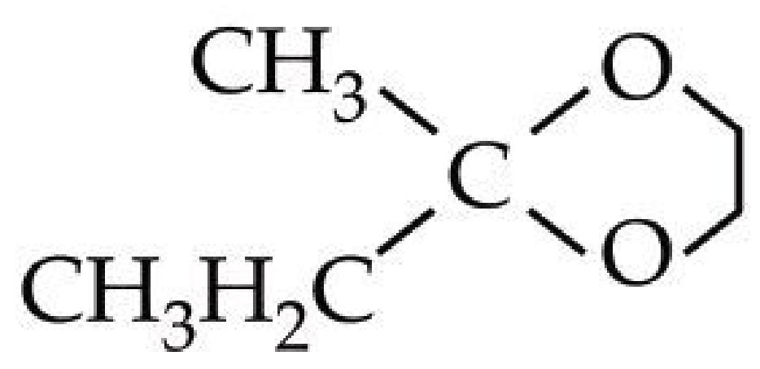
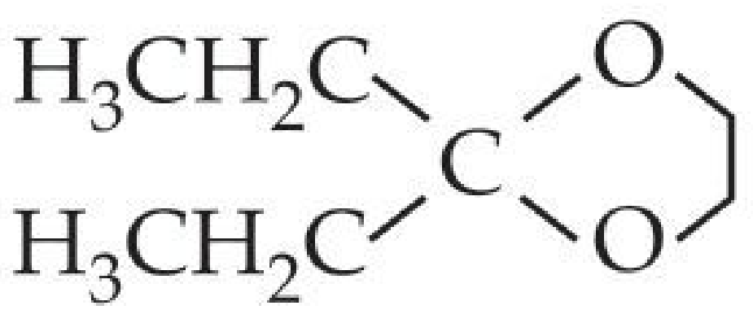
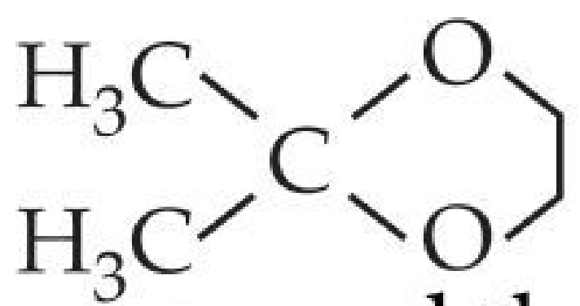
*For latest updates visit www.sofworld.org

7. What is the product when butanone reacts with ethylene glycol in presence of HCl gas?

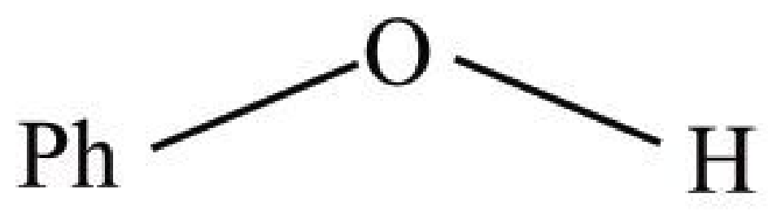
A. 

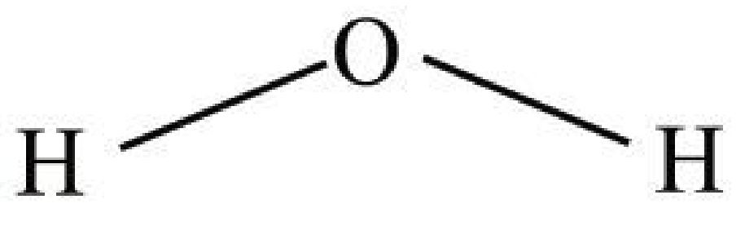
B. 

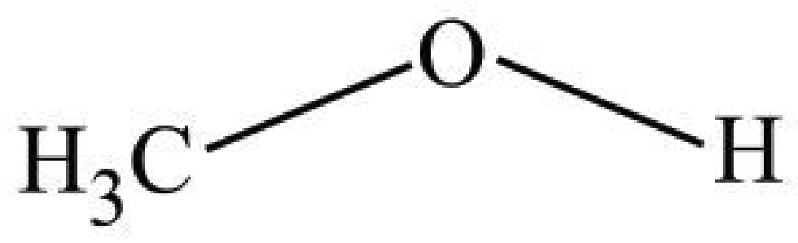
C. 

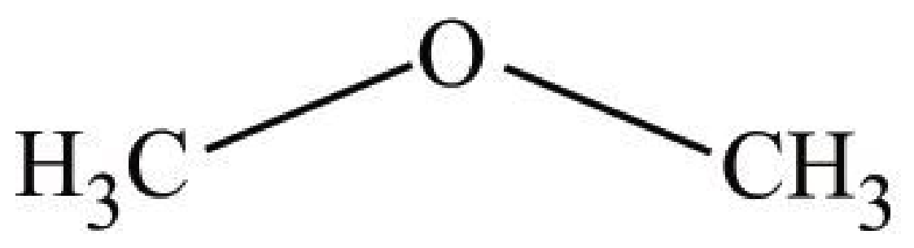
D. None of these.

8. The compound that is most difficult to protonate is

A. 

B. 

C. 

D. 

9. Which of the following orders are correct?

(I) 5*d* – 5*d* > 4*d* – 4*d* > 3*d* – 3*d* (orbital overlapping)

(II) $Mn^{2+} > Fe^{2+} > Cr^{3+} > Cu^{2+}$ (magnetic moment)

(III) $Sc^{3+} > Zn^{2+} > V^{5+} > Ti^{4+}$ (magnetic nature)

(IV) Zn > Cu > Fe > Co (atomic size)

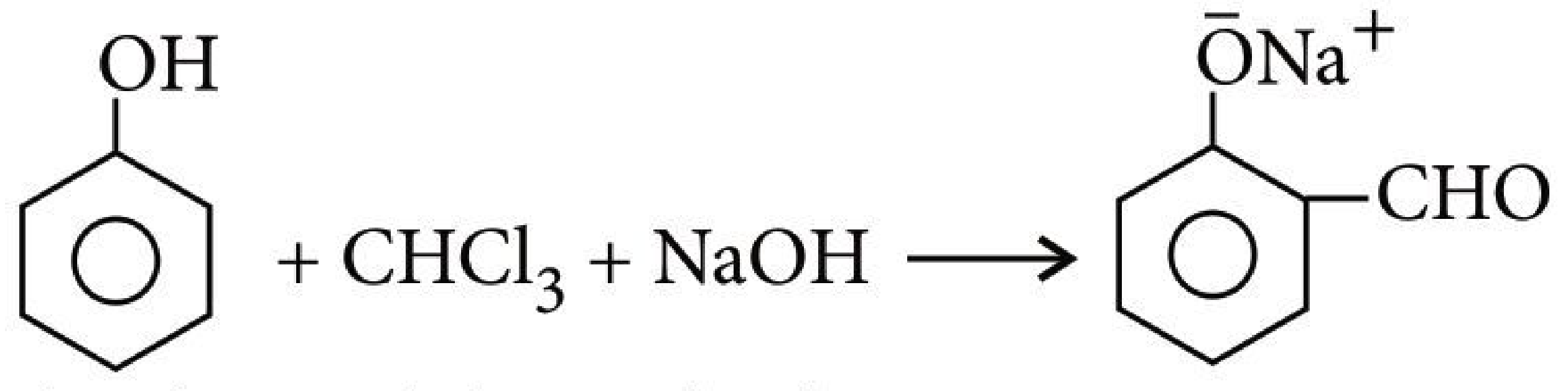
A. Only I, II

B. Only I, IV

C. Only I, II, IV

D. Only II, III, IV

10. In the reaction,



the electrophile involved is

A. dichloromethyl cation ($\overset{+}{C}HCl_2$)

B. formyl cation ($\overset{+}{C}HO$)

C. dichloromethyl anion ($\overset{-}{C}HCl_2$)

D. dichlorocarbene ($:CCl_2$)

11. A square planar complex is formed by hybridization of which atomic orbitals?

A. s, p_x, p_y, d_{yz}

B. $s, p_x, p_y, d_{x^2-y^2}$

C. s, p_x, p_y, d_{z^2}

D. s, p_x, p_y, d_{xy}

12. Which one of the following pairs is not correctly matched?

A. $>C=O \xrightarrow{\text{Clemmensen's reduction}} >CH_2$

B. $>C=O \xrightarrow{\text{Wolff-Kishner reduction}} >CHOH$

C. $-COCl \xrightarrow{\text{Rosenmund's reduction}} -CHO$

D. $-C\equiv N \xrightarrow{\text{Stephen reduction}} -CHO$

13. The activation energy of a reaction can be determined by

A. changing the concentration of reactants

B. evaluating rate constant at standard temperature

C. evaluating rate constant at two different temperatures

D. by doubling concentration of reactants.

14. The degree of dissociation (α) of a weak electrolyte A_xB_y is related to van't Hoff factor (*i*) by the expression

A. $\alpha = \frac{i-1}{(x+y-1)}$

B. $\alpha = \frac{i-1}{x+y+1}$

C. $\alpha = \frac{x+y-1}{i-1}$

D. $\alpha = \frac{x+y+1}{i-1}$

15. A hypothetical reaction; $A_2 + B_2 \longrightarrow 2AB$ follows the following mechanism:

$A_2 \rightleftharpoons A + A$ .... fast

$A + B_2 \longrightarrow AB + B$ .... slow

$A + B \longrightarrow AB$ .... fast

The order of the overall reaction is

A. 2 B. 3/2 C. 1 D. 0

ACHIEVERS SECTION

16. Lanthanoids are

A. 14 elements in the sixth period (atomic no. 90 to 103) that are filling 4*f*-sublevel

B. 14 elements in the seventh period (atomic no. 90 to 103) that are filling 5*f*-sublevel

C. 14 elements in the sixth period (atomic no. 58 to 71) that are filling the 4*f*-sublevel

D. 14 elements in the seventh period (atomic no. 50 to 64) that are filling 4*f*-sublevel.

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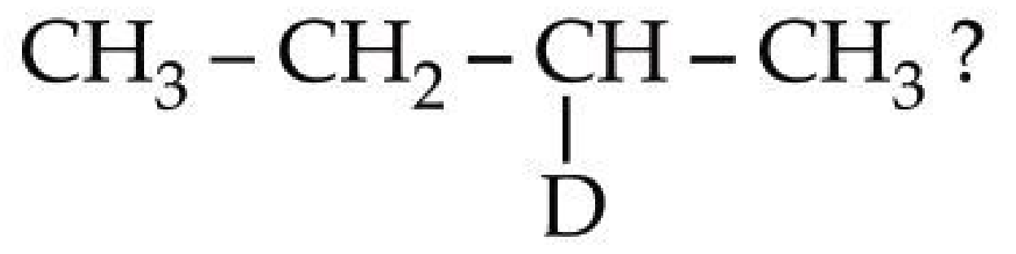
17. An organic compound of molecular formula C_3H_6O does not produce any precipitate with 2,4-dinitrophenyl hydrazine and does not react with sodium metal. This compound is

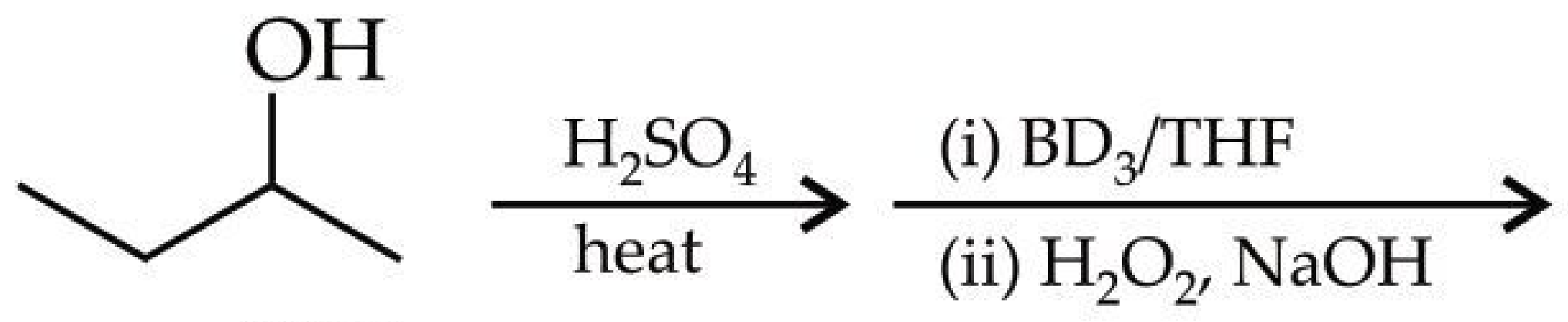
A. CH_3COCH_3 B. $CH_2{=}CH-OCH_3$

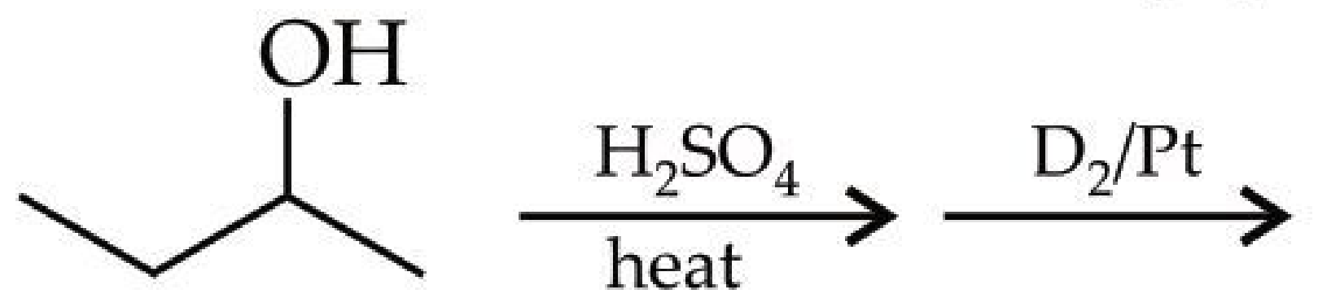
C. CH_3CH_2CHO D. $CH_2{=}CHCH_2OH$

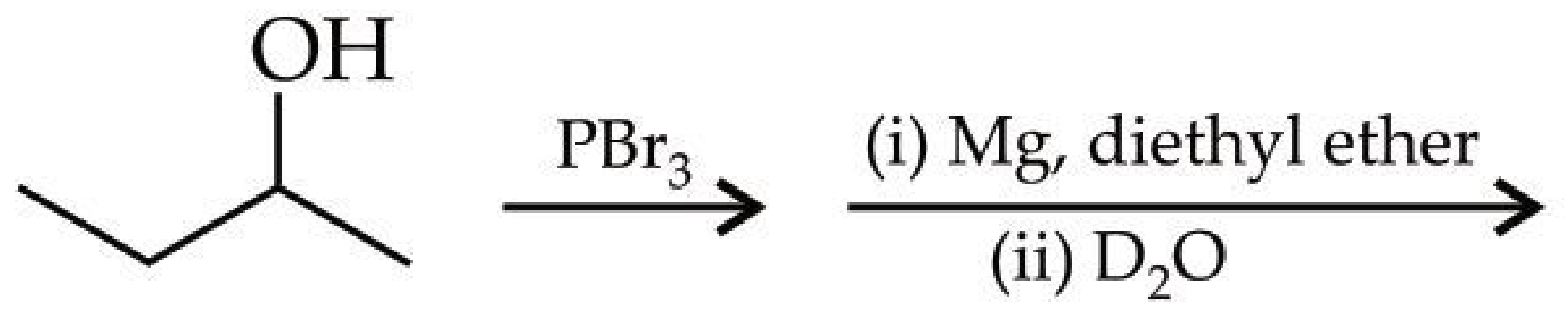
18. Which of the following reactions would convert 2-butanol into deuterated compound

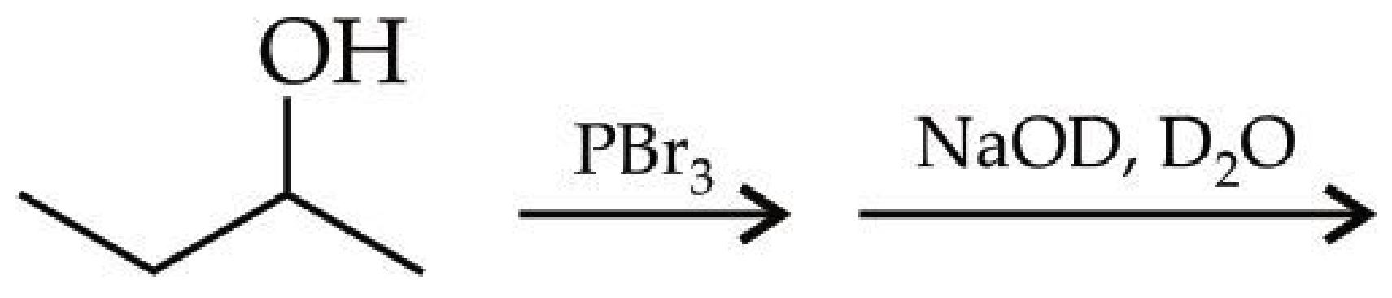


$CH_3-CH_2-\underset{|\atop D}{CH}-CH_3$?

A. 

B. 

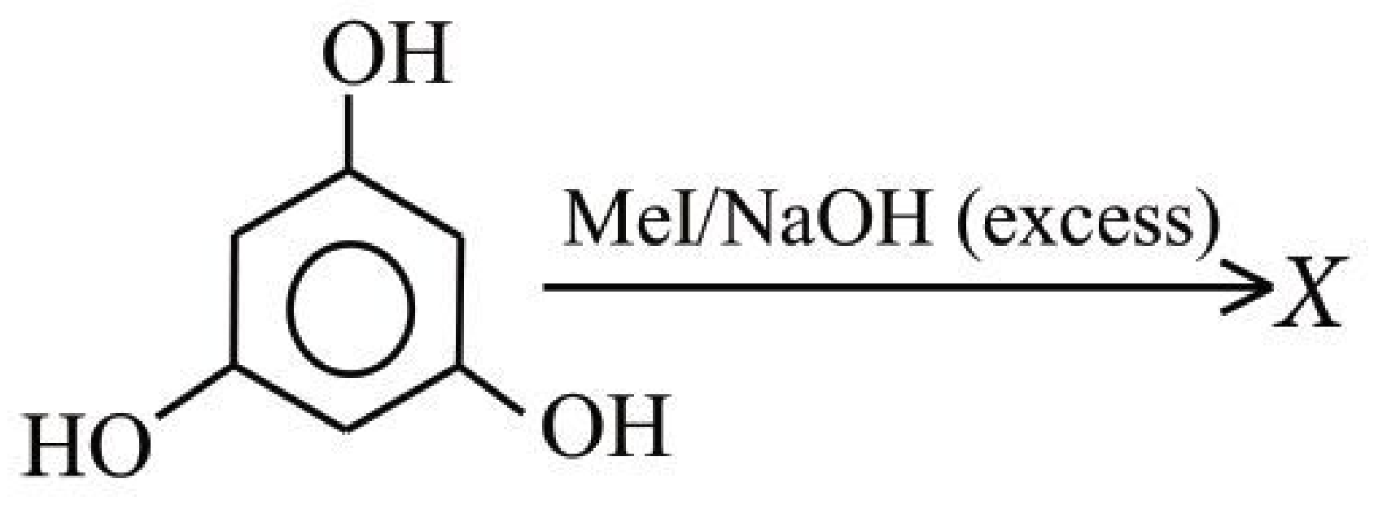
C. 

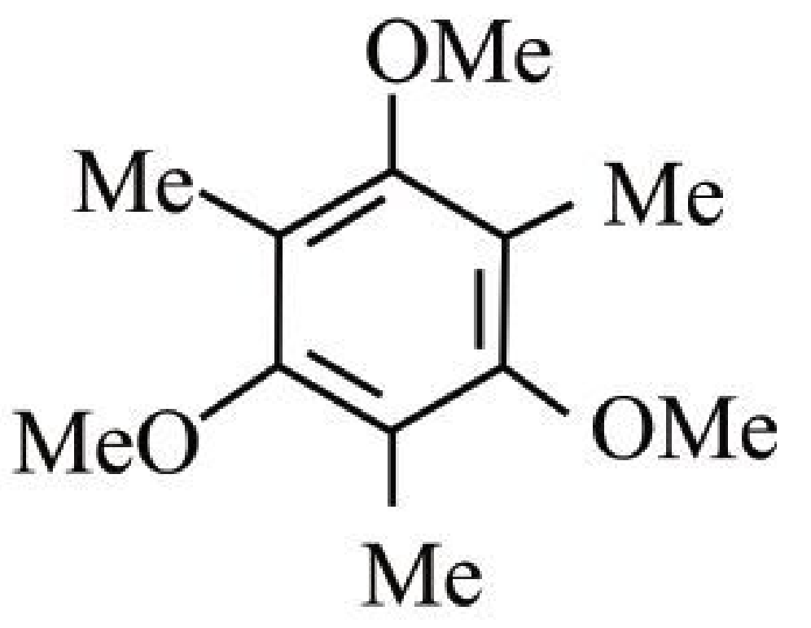
D. 

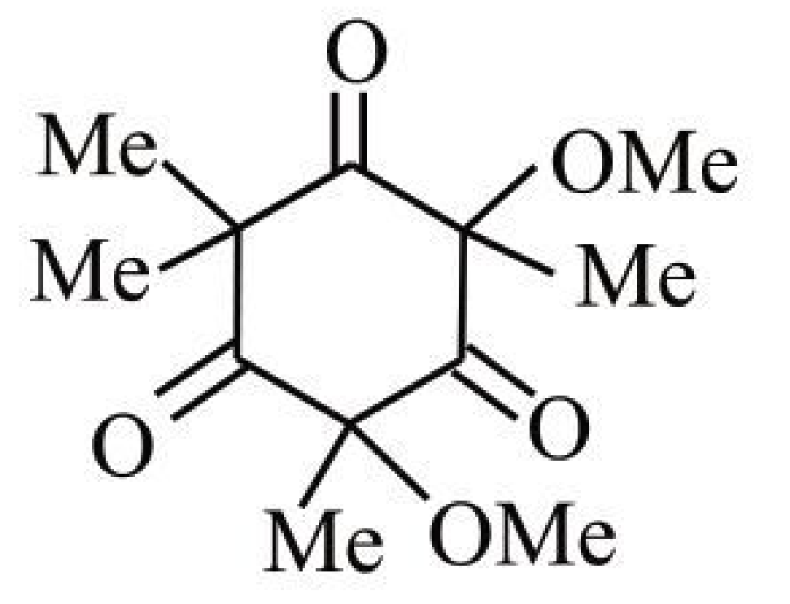
19. For the square planar complex [*Mabcd*] (where *M* = central metal and *a*, *b*, *c* and *d* are monodentate ligands), the number of possible geometrical isomers are

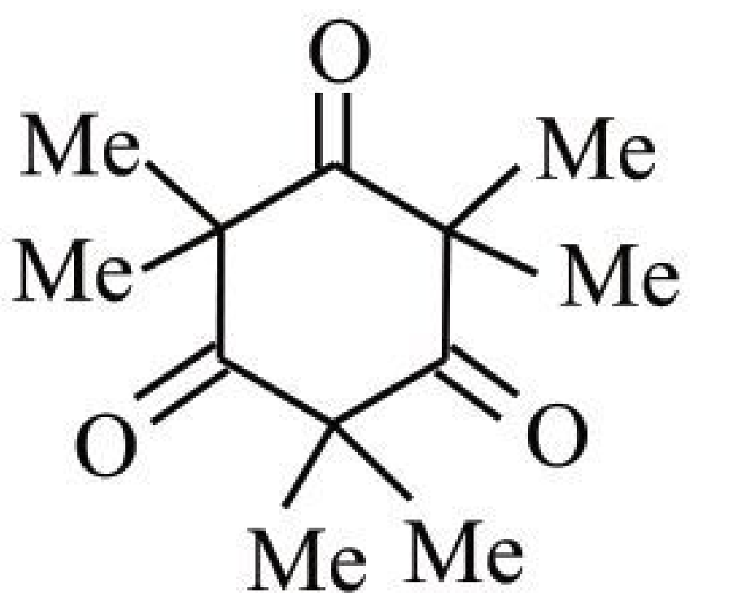
A. 1 B. 2 C. 3 D. 4

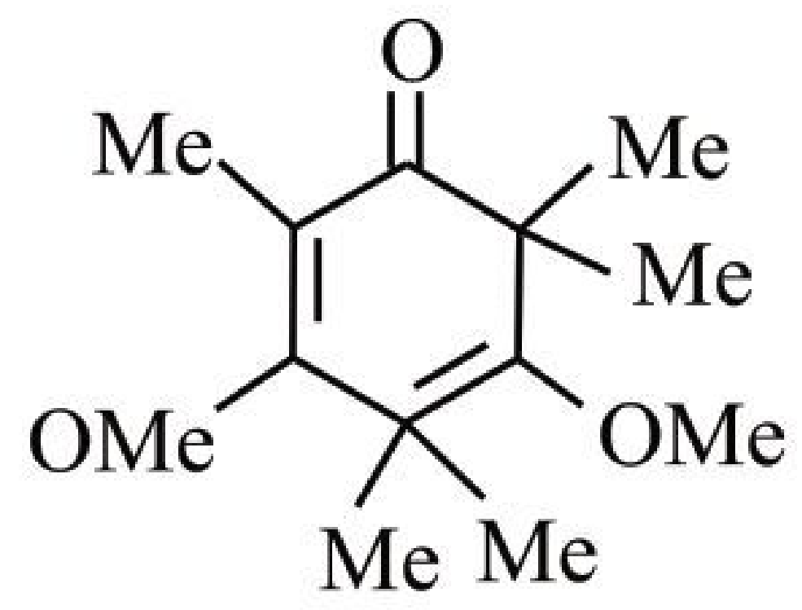
20. Identify the product '*X*' in the following reaction.



A. 

B. 

C. 

D. 

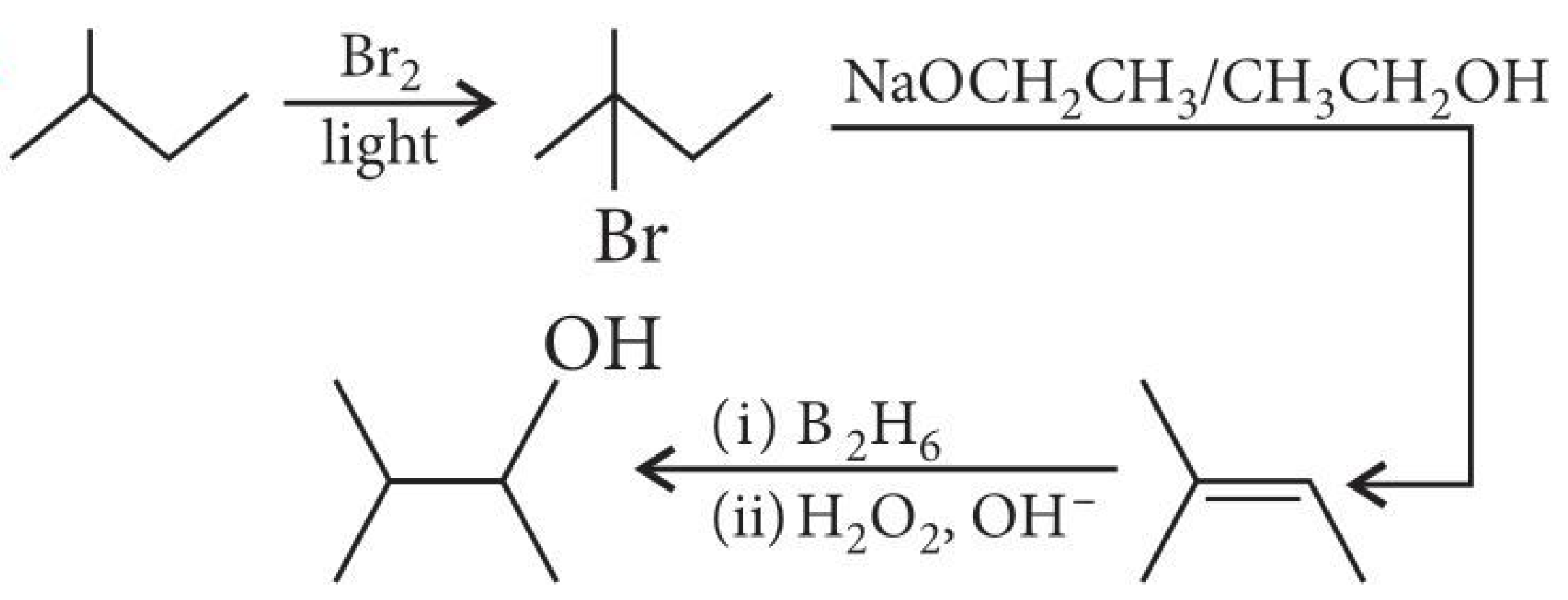
Darken your choice with HB Pencil

1.	Ⓐ Ⓑ Ⓒ Ⓓ	5.	Ⓐ Ⓑ Ⓒ Ⓓ	9.	Ⓐ Ⓑ Ⓒ Ⓓ	13.	Ⓐ Ⓑ Ⓒ Ⓓ	17.	Ⓐ Ⓑ Ⓒ Ⓓ
2.	Ⓐ Ⓑ Ⓒ Ⓓ	6.	Ⓐ Ⓑ Ⓒ Ⓓ	10.	Ⓐ Ⓑ Ⓒ Ⓓ	14.	Ⓐ Ⓑ Ⓒ Ⓓ	18.	Ⓐ Ⓑ Ⓒ Ⓓ
3.	Ⓐ Ⓑ Ⓒ Ⓓ	7.	Ⓐ Ⓑ Ⓒ Ⓓ	11.	Ⓐ Ⓑ Ⓒ Ⓓ	15.	Ⓐ Ⓑ Ⓒ Ⓓ	19.	Ⓐ Ⓑ Ⓒ Ⓓ
4.	Ⓐ Ⓑ Ⓒ Ⓓ	8.	Ⓐ Ⓑ Ⓒ Ⓓ	12.	Ⓐ Ⓑ Ⓒ Ⓓ	16.	Ⓐ Ⓑ Ⓒ Ⓓ	20.	Ⓐ Ⓑ Ⓒ Ⓓ

SOLUTIONS

1. (B)

2. (C) :



3. (B) : *R* = *K*[*A*] [*B*]. The unit of rate constant of 2nd order is L mol^{-1} s^{-1}.

4. (B)

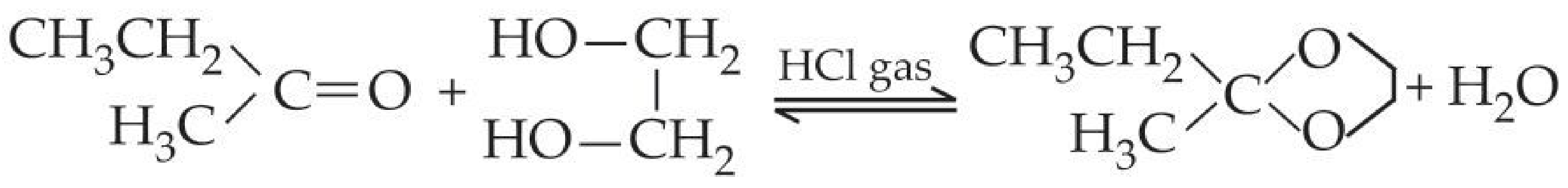
5. (A) : Molality, $m = \frac{w_B}{m_B} \times \frac{1000}{w_A}$

$b = \frac{c}{m_B} \times \frac{1000}{(a-c)}$; $m_B = \frac{c}{b} \times \frac{1000}{(a-c)}$

6. (A) : $FeCr_2O_4 + Na_2CO_3 + O_2 \xrightarrow{\text{Heat}} 2Na_2CrO_4$

$\xrightarrow[\text{Heat}]{NH_4Cl} Cr_2O_3 \xrightarrow{2Al} Al_2O_3 + 2Cr$

7. (A) : When butanone reacts with ethylene glycol in presence of HCl, it forms a ketal.



8. (A) : In $Ph-\ddot{O}-H$, the lone pair of oxygen is in conjugation with phenyl group so, it is least basic among the given compounds and is most difficult to protonate.

9. (C) **10. (D)**

11. (B) : Square planar complex is formed by dsp^2 hybridisation involving the orbitals $(n-1)d_{x^2-y^2}$, ns, np_x and np_y.

12. (B) : $\rangle C{=}O \xrightarrow{\text{Wolff–Kishner reduction}} \rangle CH_2$

13. (C) : The activation energy of a reaction can be determined by evaluating rate constant at two different temperatures by using the following expression :

$$\log\frac{k_2}{k_1} = \frac{E_a}{2.303\,R}\left[\frac{T_2-T_1}{T_1 T_2}\right]$$

14. (A) : $$\begin{array}{ccc} A_xB_y & \rightleftharpoons & xA^+ + yB^- \\ 1-\alpha & & x\alpha \quad y\alpha \end{array}$$

Total = $1 + \alpha(x + y - 1)$ or $i = 1 + \alpha(x + y - 1)$

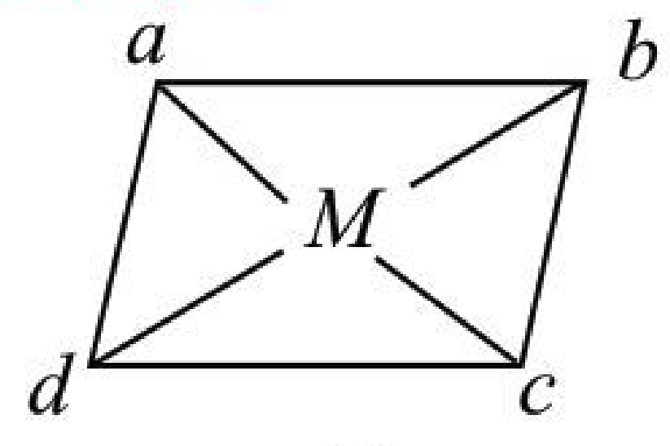
or $\alpha = \dfrac{i-1}{x+y-1}$

15. (B) **16. (C)**

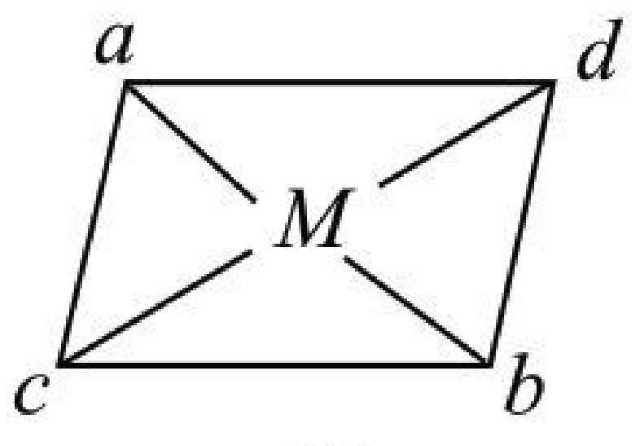
17. (B) : Since the compound does not react with 2,4-dinitrophenyl hydrazine, it cannot be carbonyl compound. No reaction with sodium metal indicates that compound cannot be an alcohol. Hence it could only be $CH_2{=}CH{-}O{-}CH_3$.

18. (C)

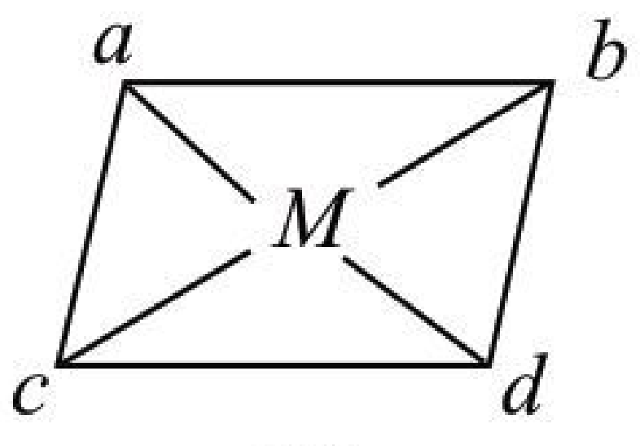
19. (C) :



(i)

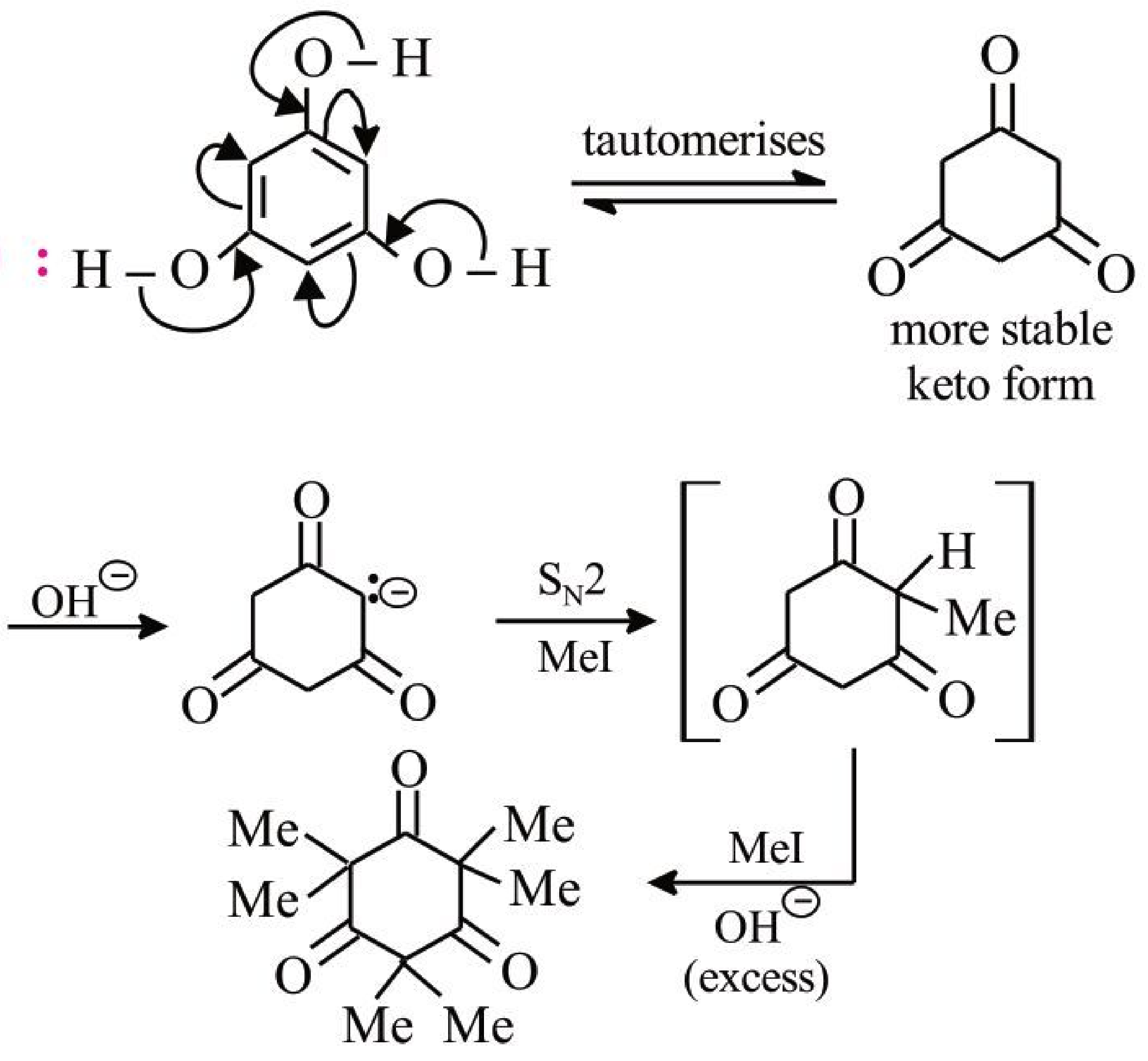


(ii)



(iii)

20. (C) :



The more stable keto form gives α-alkylation reaction.

For other sections/subjects please refer to Physics For You and Biology Today

◆ ◆

Ajinomoto : How the Japanese seasoning became popular globally

THE DELHI High Court recently halted the release of a film titled 'Ajinomoto', after a Japan-based seasoning manufacturer claimed infringement of its 113-year-old registered trademark 'AJI-NO-MOTO', which is primarily used for its product, monosodium glutamate. Makers of the seasoning also claimed using the word to imply a negative characteristic, as suggested by the filmmakers, "is bound to severely prejudice" against the product.

The origins of MSG

In 1908, Kikunae Ikeda. a chemistry professor at Tokyo's Imperial University, reached out to a pharmaceutical firm, Suzuki Pharmaceutical, for help in commercialising a food additive that he had been researching. Ikeda had been inquiring about the reason for the distinctive flavour of kelp, an algae.

The story goes that while savouring a bowl of tofu in a broth made from kelp, he became convinced there was another basic taste, different from sweet, salty, sour, and bitter. He called it umami, playing on the Japanese word for delicious. Ikeda's studies led him to glutamate, one of the most common amino acids in foods-and in the human body. With a dash of sodium, it became monosodium glutamate (MSG). A tasting confirmed the compound's culinary promise.

In less than a year, the patent office gave its approval to Ajinomoto – a seasoning made by breaking down wheat with hydrochloric acid. The name, literally "quintessence of flavour" was chosen by Saburosuke Suzuki, the then-head of Suzuki Pharma.

But the production process would corrode the vessels. Moreover, all of Suzuki's marketing couldn't cloud the fact that Ajinomoto was expensive. Finding very little success amongst restaurants, the company began targeting homemakers. But Japanese women, who would regard frugality as a necessary virtue, would find it difficult to regard Ajinomoto as necessary for their kitchens.

Making it accessible

According to historian Jordan Sand, the company used several tactics to woo customers. Its ads depicted a woman sporting a white apron and a Westen-influenced sokutatsu hairstyle. Ajinomoto was sold in slender glass bottles that resembled perfume holders. The marketers also appealed to the homemakers' new sense of identity "as a culinary professional". It roped in cultural figures, including the popular writer, Murai Gensai. Even then, it wasn't till the late 1930s that an Ajinomoto shaker would become as ubiquitous in Japanese homes as ones for salt.

By then, the company had refined its production process. More importantly, it had taken Ajinomoto to China. Initially, Ajinomoto billboards were seen as symbols of Japanese imperialism. But in a country undergoing a churn, Suzuki's marketing of Ajinomoto as a flavour for modern times struck a chord. In less than a decade, the company had a Chinese competitor, Tian Chu (Heavenly Kitchen). Sand says Ajinomoto's Chinese maker touted its product as the "national taste essence; An entirely domestic product; Not the same as the import! Better than Ajinomoto and fairly priced".

Ajinomoto goes global

Japanese immigrants took Ajinomoto to Hawaii, and the Chinese diaspora took it to North America. In 'Cook at Home in Chinese', published in 1938, Henry Low - often credited for inventing the egg roll - listed it as one of the five "Chinese staples one needed to start cooking Chinese in an American kitchen".

Around the same time, makers of canned soups-Campbell Soup, for example - began using MSG as a flavour enhancer.

According to Sand, the key to Ajinomoto's success lay in repackaging its product in different ways.

Another spurt of popularity came when American soldiers posted in Japan during the Second World War returned home. This was also the time when the American military was trying to find ways to improve the taste of the soldiers' bland food rations. The new field of frozen foods was another propitious avenue for the flavour enhancer.

Doubts over safety

But in the late 1960s, especially in the US, consumer trust in food products with chemicals broke down, fueled in large measure by food safety and environmental movements. At times they coalesced - inadvertently-with some racist inclinations: Symptoms such as numbness and a fast heartbeat often came to be referred to as the "Chinese restaurant syndrome".

In the '70s, Ajinomoto sales fell for the first time in 40 years. But this was also the time that MSG was finding new shores-India, for instance. It has continued to have its detractors, even as food safety agencies, such as the US FDA, have pronounced MSG safe. The doubters persist even when revisionist culinary studies have revealed that a lot of the bad press Ajinomoto got was because poorly designed "food safety studies" used five to 30 times the normal amount.

Courtesy : The Indian Express

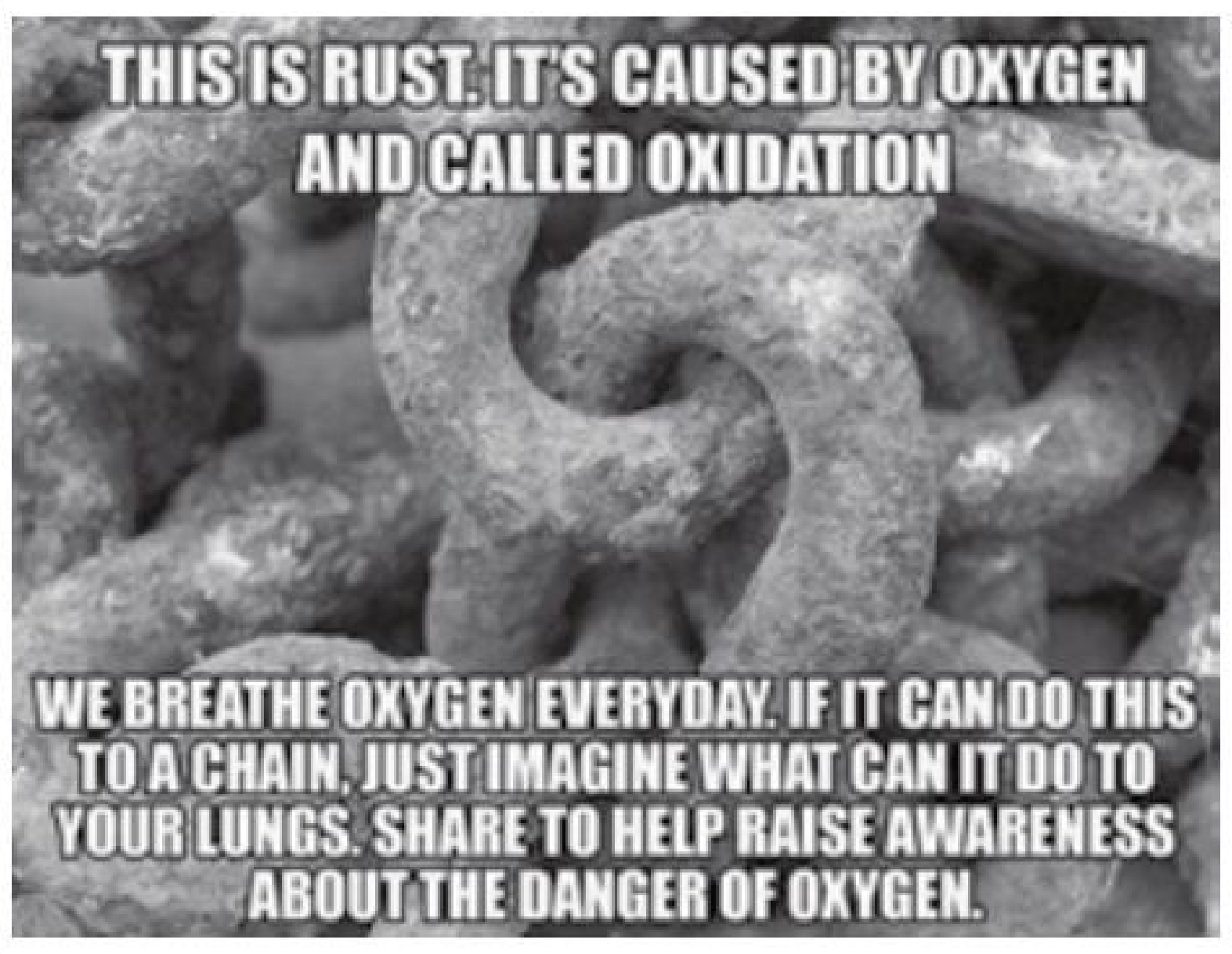
Quiz CLUB

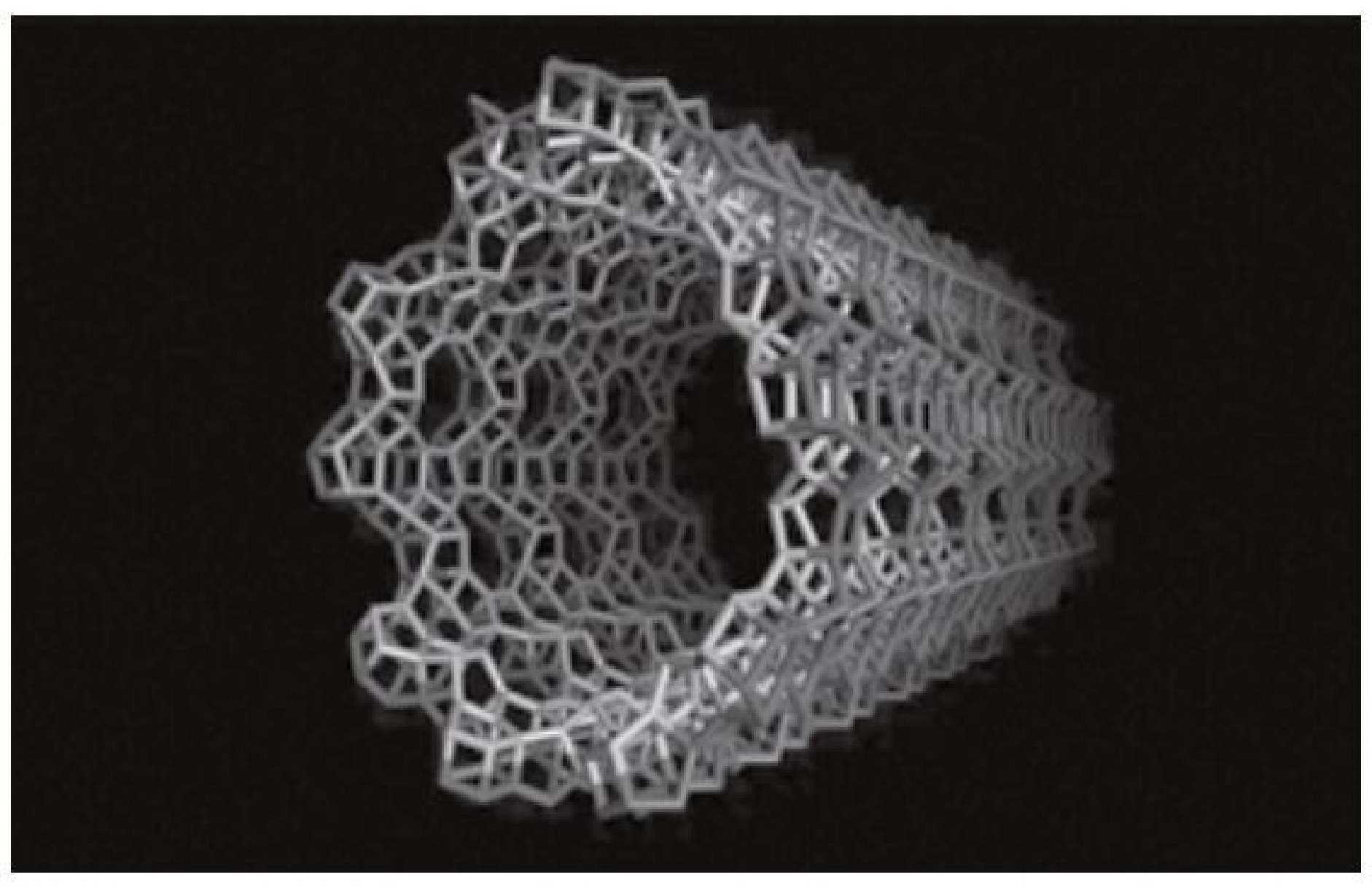
Unlock Your Knowledge!

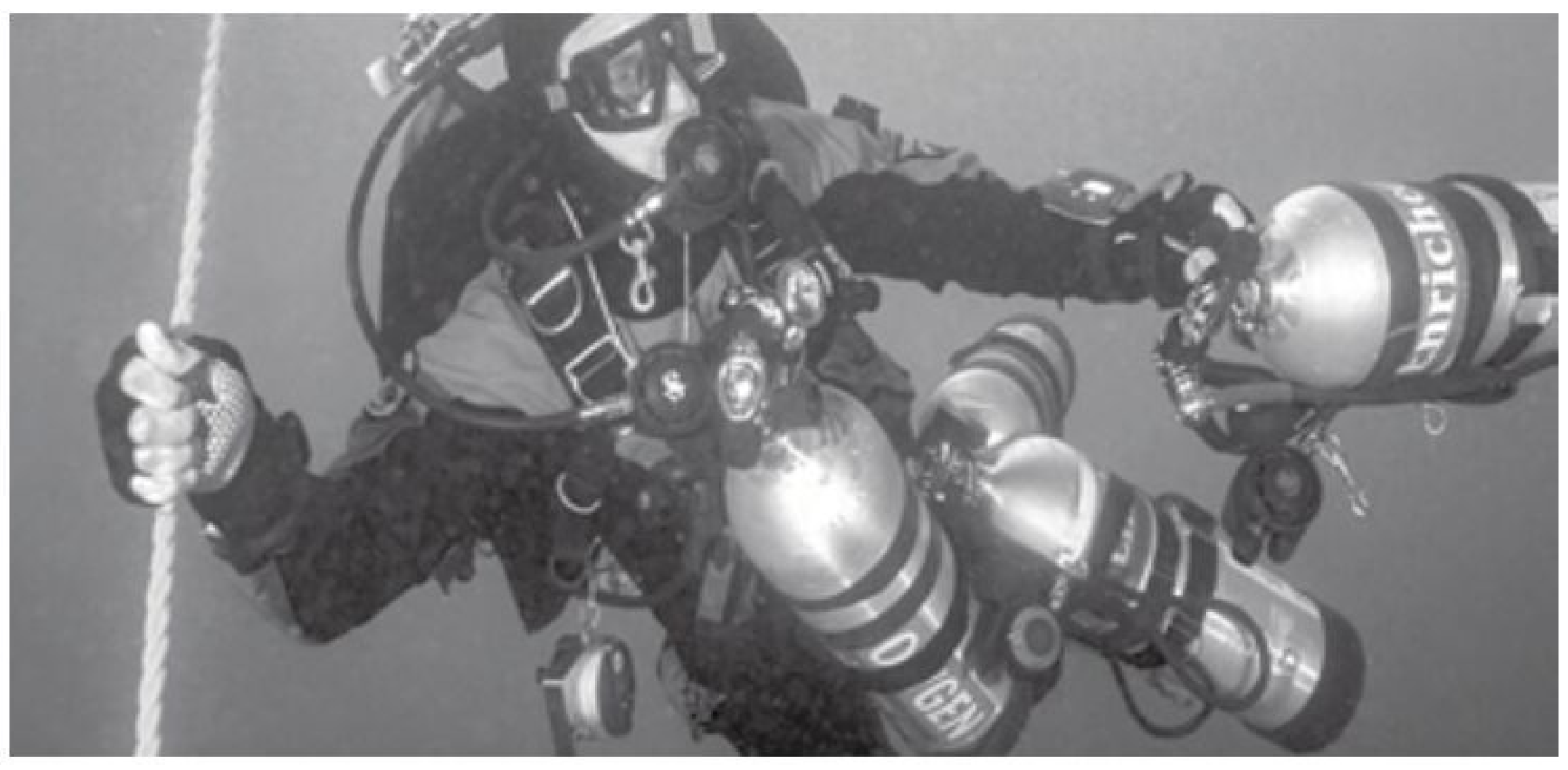
1. The name of the most abundant gas which causes explosion in coal mines is _______.
2. The common name of analgesic and antipyretic drug acetylsalicylic acid is ______.
3. The common name of calcium sulphate hemihydrate is _______.
4. The polymer that is used in the manufacture of paints and lacquers is _______.
5. The name of catalyst used in the production of ammonia by Haber's process is _______.
6. An allotrope of phosphorus that glows in the dark is _______.
7. The noble gas which doesn't exist in the atmosphere is _______.
8. The acid which is used to remove ink stains is _______.
9. The name of concentrated solution of sodium chloride is _______.
10. To avoid bends, divers use oxygen diluted with _______ gas because it is less soluble in blood.
11. The gas used for artificial ripening of fruits is _______.
12. The number of gram-molecules of oxygen in 6.02×10^{24} CO molecules is _______.
13. The maximum number of isomers for an alkene with molecular formula C_4H_8 is _______.
14. The half-life period of an isotope is 2 hours. After 6 hours, the fraction of the initial quantity of the isotope left behind will be _______.
15. The number of waves made by an electron moving in an orbit having maximum magnetic quantum number +3 is _______.
16. The chemical formula of haematite ore is _______.
17. The chemical formula of rust is _______.
18. The shape-selective catalysts having honeycomb like structures that are widely used as catalysts in petrochemical industries are _______.
19. An enzyme that catalyses the hydrolysis of urea forming ammonia and carbon dioxide is _______.
20. The number of different types of crystal systems on the basis of cell dimensions and axial angles is _______.

◆◆

Readers can send their responses at editor@mtg.in or post us with complete address by 10th of every month. Winners' names and answers will be published in next issue.


THIS IS RUST. IT'S CAUSED BY OXYGEN AND CALLED OXIDATION
WE BREATHE OXYGEN EVERYDAY. IF IT CAN DO THIS TO A CHAIN, JUST IMAGINE WHAT CAN IT DO TO YOUR LUNGS. SHARE TO HELP RAISE AWARENESS ABOUT THE DANGER OF OXYGEN.





GK CORNER

Enhance Your General Knowledge with Current Updates!

APPOINTMENTS AND NOMINATIONS

- Odisha anthropologist Prof. Kishor Kumar Basa has been appointed as the chairman of National Monuments Authority (NMA). He is currently the Vice Chancellor of Maharaja Sriram Chandra Bhanja Deo University, Baripada and will be the first social scientist from Odisha to hold such a prestigious position.
- Switzerland Tourism has appointed Olympic gold medalist Neeraj Chopra as the 'Friendship Ambassador' on 11 November 2022. In his new role, the talented Indian sports superstar will showcase and promote the adventurous, sporty and stunning outdoors of Switzerland to Indian travellers.
- WhatsApp India head Abhijit Bose and Meta India Director of Public Policy Rajiv Aggarwal have left the company, less than two weeks after the departure of Meta India country head Ajit Mohan. These developments come against the backdrop of Facebook's parent company laying off 11,000 people worldwide on November 9.
- ICAR-Sugarcane Breeding Institute got its first-ever woman director in over a century of the institution's existence as Dr. G. Hemaprabha till 2024 on the recommendation of the Agricultural Scientists Recruitment Board, New Delhi under the Union Minister of Agriculture and Farmers Welfare.
- The 14th Dalai Lama was conferred the Gandhi Mandela Award 2022 at Thekchen Choeling in Dharamshala's Mcleod Ganj by Himachal Pradesh governor Rajendra Vishwanath Arlekar.

  The award is given to personalities who have carried forward the legacies of Gandhi and Mandela by making significant contributions in the fields of Peace, Social Welfare, Culture, Environment, Education, Healthcare, Sports and Innovation.
- The Federation of Indian Chambers of Commerce and Industry (FICCI) felicitated Rajendra Singh Pawar, Chairman and Co-Founder of NIIT, with 'Lifetime Achievement Award 2022' at the 8th FICCI Higher Education Excellence Awards ceremony. The award recognises the immense contribution and exemplary work in the field of education as well as creating the IT training industry.

  The Federation of Indian Chambers of Commerce and Industry (FICCI) named Subhrakant Panda as its next president.

  Panda, the Managing Director of Indian Metals and Ferro Alloys Ltd. (IMFA), currently serves as the senior vice-president of FICCI.
- For the first time in the history of Central Reserve Police Force (CRPF), two women officers reached the rank of Inspector General (IG)– Seema Dhundia and Annie Abraham.
- On 7 November 2022, retired High Court Chief Justice Rituraj Awasthi has been appointed as the chairperson of the 22nd Law Commission of India which was constituted in 2020. The Law Commission of India is a non-statutory body constituted by the Government of India from time to time.

- The multiple Asian Games gold medalist and fourth place finisher in the 1984 Los Angeles Olympics 400m hurdles final, the 58-year-old P.T. Usha was declared as the new president of the Indian Olympic Association (IOA) on December 10. The elections were held under the supervision of retired Supreme Court judge L. Nageswara Rao.
- Retail jewellery major Malabar Gold and Diamonds has become the first jeweller in India to import 25 kg gold under the Comprehensive Economic Partnership Agreement (CEPA) between India and the UAE. The gold has been imported through ICICI Bank with one percent duty rebate under the agreement.
- Avani Lekhara, who won two medals at the Tokyo 2020 Paralympics, was recognized as the Para Sports Person of the Year while Shrey Kadyan was recognized as the Special Sportsperson of the Year.
- Senior IAS officer, Gaurav Dwivedi was appointed the Chief Executive Officer of public broadcaster Prasar Bharati. Mr. Dwivedi will have a five-year tenure from the date he assumes charge. Earlier, he was the Chief Executive Officer of MyGov India (citizen engagement platform of the government).
- Senior-most Supreme Court judge and Chief Justice of India-designate Dhananjaya Y. Chandrachud is all set to become the 50th head of the Indian judiciary when President Droupadi Murmu would administer the oath of office to him at Rashtrapati Bhavan.

Test Yourself!

1. Who among the following is honoured with 'Champions of the Earth' award by UNEP?
   (a) Partha Bhaduri
   (b) Dr. Purnima Devi Barman
   (c) Seema Punia
   (d) Shubham Dhananjay Vanmali
2. Who is elected as the president of the Indian Olympic Association (IOA) 2022?
   (a) Dutee Chand (b) C.A. Bhavani Devi
   (c) P.T. Usha (d) Dola Banerjee
3. Who among the following received "Gandhi Mandela Award 2022" ?
   (a) Anurag Thakur (b) Narendra Modi
   (c) 14th Dalai Lama (d) Volodymyr Zelenskyy
4. Which among the following is recognised as the Para Sports Person of the Year 2022?
   (a) Pramod Bhagat (b) Deepa Malik
   (c) Sumit Antil (d) Avani Lekhara
5. The Ministry of Earth and Science launched 'Deep Ocean Mission'. It is related to
   (a) development of self propelled submarine
   (b) measure ocean climate change
   (c) protecting corals
   (d) integrated mining system for polymetallic nodules.
6. Who among the following was elected the next President of Brazil after Jair Bolsonaro?
   (a) Paulo Coelho
   (b) Luiz Inácio Lula da Silva
   (c) Benito Mussolini (d) Dilma Rousseff
7. Who among the following is newly appointed CEO of public broadcaster Prasar Bharati?
   (a) Gaurav Dwivedi (b) Kishor Kumar Basa
   (c) Arvind Virmani (d) Sandhya Devanathan
8. Recently 'Sindhuja-I' was in news, it is a/an
   (a) device which converts heat flux into electric energy
   (b) device that changes the state of matter
   (c) ocean wave energy converter
   (d) electro-mechanical device.
9. The 22nd edition of the FIFA World Cup took place in Qatar. Who is the FIFA President 2022?
   (a) Gianni Infantino
   (b) Tedros Adhanom Ghebreyesus
   (c) Joan Donoghue (d) David Malpass
10. Who has been appointed as the Chairperson of the 22nd Law Commission of India which was constituted in 2020?
    (a) Dhananjaya Y. Chandrachud
    (b) Arun Goel
    (c) Rajiv Kumar (d) Rituraj Awasthi

Answer Key

1.	(b)	**2.**	(c)	**3.**	(c)	**4.**	(d)	**5.**	(d)
6.	(b)	**7.**	(a)	**8.**	(c)	**9.**	(a)	**10.**	(d)

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◆ ◆

CLASS-XI

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Unit 5 Redox Reactions | Hydrogen

REDOX REACTIONS

OXIDATION-REDUCTION REACTIONS

- Several chemical reactions involve transfer of electrons from one chemical substance to another. These electron transfer reactions are termed as oxidation-reduction reactions.

Old theories based on	Oxidation	Reduction
Oxygen	Addition of oxygen	Removal of oxygen
Hydrogen	Removal of hydrogen	Addition of hydrogen
Electronegative elements	Addition of electronegative element	Removal of electronegative element
Electropositive elements	Removal of electropositive element	Addition of electropositive element
New theories based on	**Oxidation**	**Reduction**
Electron	Loss of electron(s)	Gain of electron(s)
Oxidation number	Increase in oxidation number	Decrease in oxidation number

- **Oxidising agent :** The substance which brings oxidation of other substance and gets itself reduced is known as oxidising agent. Oxidising agents are electron(s) acceptors. Thus, an oxidising agent provides oxygen or removes hydrogen or removes electrons from other substance. These reagents are also called oxidants.

  $$S + 6HNO_3 \longrightarrow H_2SO_4 + 2H_2O + 6NO_2$$

  Oxidising agent

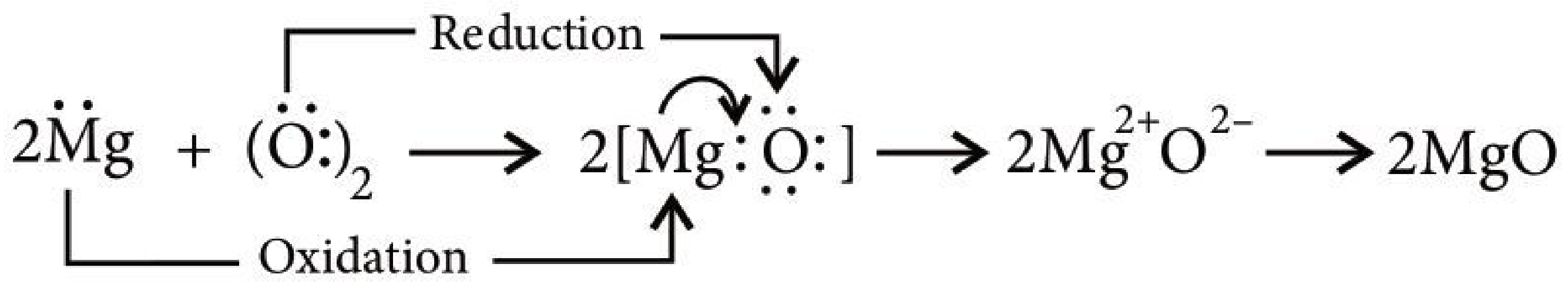
- **Reducing agent :** The substance which brings reduction of other substance and gets itself oxidised is known as reducing agent. Reducing agents are electron(s) donors. Thus, a reducing agent removes oxygen or provides hydrogen or provides electrons to other substances. These reagents are also called reductants

  $$ZnO + C \longrightarrow Zn + CO$$

  Reducing agent

REDOX REACTIONS

- A reaction in which electrons are transferred from one reactant to another is called redox reaction. Thus, a redox reaction involves both oxidation and reduction. These reactions involve change in oxidation number of interacting species.



OXIDATION NUMBER

- The oxidation number is the charge on an atom which it has or it appears to have in its combined state.
- **Some rules for assigning oxidation number are as follows :**
  - The oxidation number of atoms of all the elements in the free state is zero.
  - For monoatomic ions, the oxidation number of atom is equal to its charge.
  - The oxidation number of oxygen in most compounds is –2 except in peroxides (–1),

superoxides (– 1/2), oxygen difluoride, OF_2(+2) and dioxygen difluoride, O_2F_2 (+1).
  - The oxidation number of hydrogen is +1, except in metal hydrides where it is –1.
  - Fluorine always has an oxidation number of –1.
  - The algebraic sum of oxidation numbers of all the atoms in a compound must be zero.
  - In polyatomic ion, the algebraic sum of all the oxidation numbers of atoms of the ion is equal to the charge on the ion.

- **Fractional oxidation state** is the average oxidation state of an element when two or more of its atoms are present in different oxidation states in a given compound.
- **Stock notation :** The method of representing oxidation state of a metal by Roman numerals I, II, III, etc., within the parenthesis is known as stock notation. For example, $FeSO_4$ as iron(II) sulphate, N_2O as nitrogen(I) oxide and $CuSO_4$ as copper(II) sulphate.
- In terms of oxidation number, oxidation involves increase in the oxidation number of the element and reduction involves decrease in the oxidation number of the element.

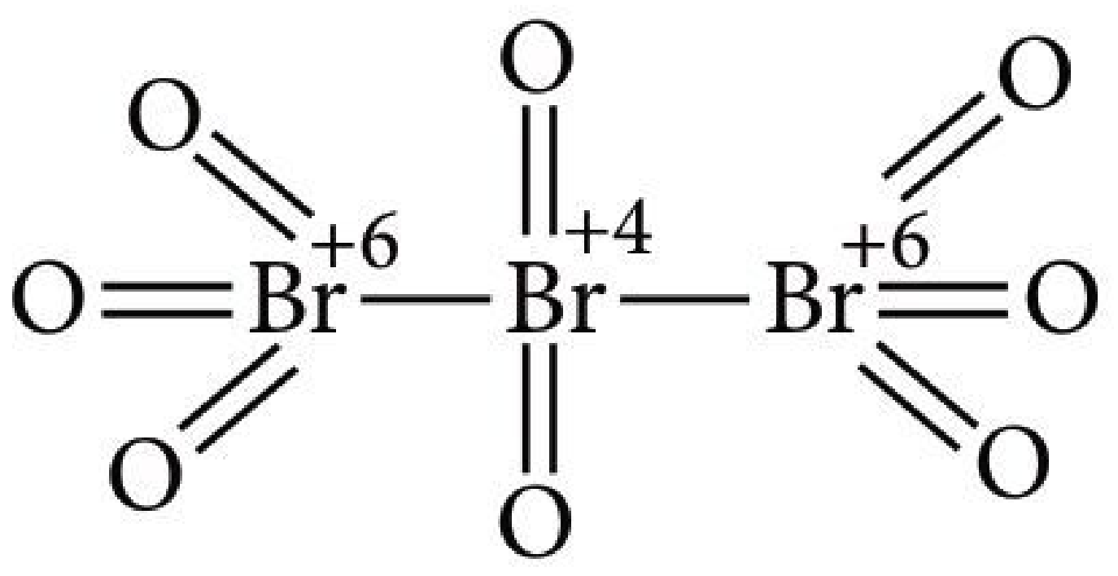
Oxidation Number of Some Important Compounds

- **Oxidation number of C in C_3O_2 (carbon suboxide) :**

$$O{=}\overset{+2}{C}{=}\overset{0}{C}{=}\overset{+2}{C}{=}O$$

Two carbon atoms have +2 oxidation state while other has zero oxidation state.

- **Oxidation number of Br in Br_3O_8 (tribromooctaoxide) :**



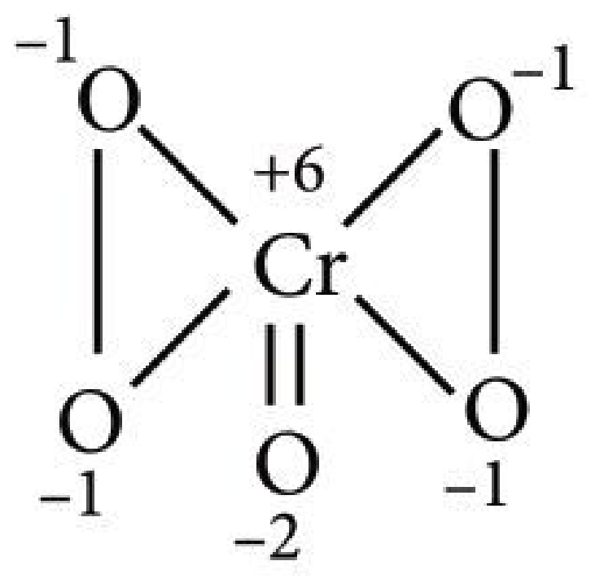
Two Br-atoms have +6 oxidation state while other one has +4 oxidation state.

- **Oxidation number of Fe in Fe_3O_4 :**

$3x - 8 = 0$ or $x = 8/3$

Here in Fe_3O_4, oxidation number is the average of those in FeO and Fe_2O_3.

- **Oxidation number of Cr in CrO_5 :** CrO_5 has two peroxo bonds and peroxo oxygen has –1 oxidation state.



Thus, $x + 4(-1) + (-2) = 0$

or $x - 6 = 0$ or $x = +6$

TYPES OF REDOX REACTIONS

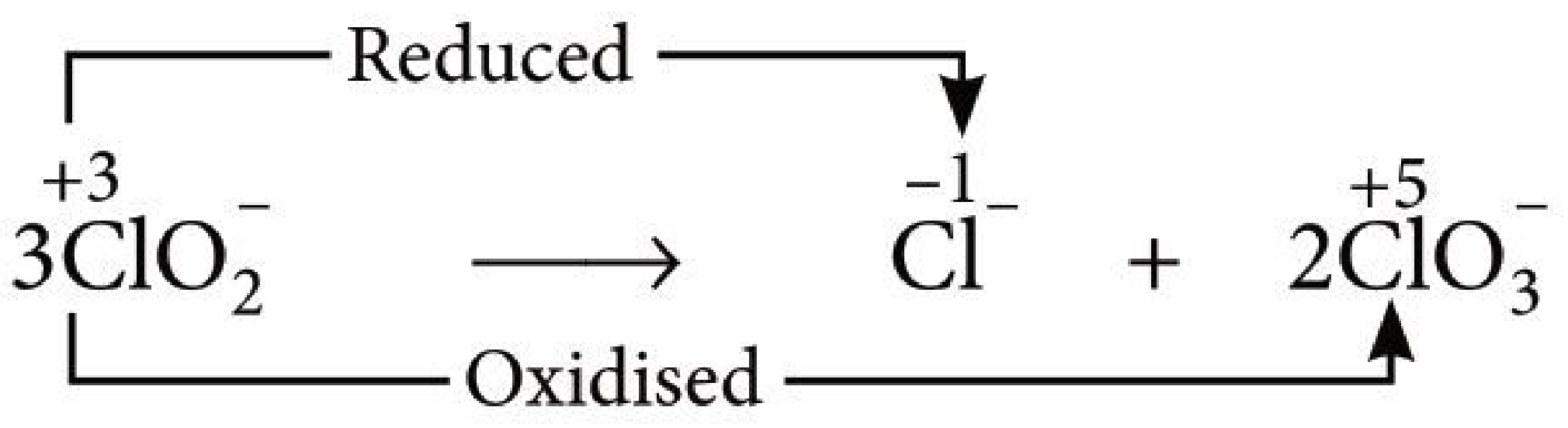
- **Combination reactions :** These are the reactions in which two atoms or molecules combine together to form a third molecule. In these reactions, at least one of the reactants must be in elemental form, *e.g.*,

$$\overset{0}{H_2}+\overset{0}{Cl_2}\rightarrow 2\overset{+1}{H}\overset{-1}{Cl}\quad ;\quad 2\overset{0}{H_2}+\overset{0}{O_2}\rightarrow 2\overset{+1}{H_2}\overset{-2}{O}$$

- **Decomposition reactions :** These are the reactions in which a molecule/compound breaks down to form two or more atoms or molecules. These are simply the reverse of combination reactions. For these reactions to be redox reactions, one of the products must be in elemental form, *e.g.*,

$$2\overset{+1}{H_2}\overset{-2}{O}\xrightarrow{\Delta}2\overset{0}{H_2}+\overset{0}{O_2}$$

- **Displacement reactions :** These are the reactions in which an atom or ion in a compound is replaced by another atom or ion. These reactions are represented as $AB + C \rightarrow AC + B$
  - **Metal displacement reaction :** If a metal atom/ion is displaced by another metal atom/ion in the reaction, it is called metal displacement reaction.
  - **Non-metal displacement reaction :** If a non-metal atom/ion is displaced by another metal atom/ion in the reaction, the reaction is called non-metal displacement reaction.
- **Disproportionation reactions :** These are the reactions in which a single species is oxidised as well as reduced simultaneously. In these reactions, the reacting species must have an element which can have at least three variable oxidation states.



$$3\overset{+3}{Cl}O_2^- \longrightarrow \overset{-1}{Cl^-} + 2\overset{+5}{Cl}O_3^-$$

MONTHLY TEST DRIVE CLASS XII ANSWER KEY

1. (a)	2. (a)	3. (a)	4. (d)	5. (b)
6. (b)	7. (b)	8. (a)	9. (a)	10. (c)
11. (d)	12. (b)	13. (d)	14. (a)	15. (a)
16. (b)	17. (b)	18. (b)	19. (d)	20. (a,b,c)
21. (a,c,d)	22. (a,d)	23. (a,b,d)	24. (90)	25. (0.0693)
26. (96500)	27. (a)	28. (b)	29. (c)	30. (a)

Balancing of Redox Reactions

- **Oxidation number method :** This method involves the following steps :

  Step 1 : Write the skeleton redox reaction.

  Step 2 : Write the oxidation number of atoms above the symbol and identify elements undergoing oxidation or reduction.

  Step 3 : Balance the increase and decrease in oxidation number by multiplying the half-reaction with suitable integer.

  Step 4 : Balance the atoms other than hydrogen and oxygen.

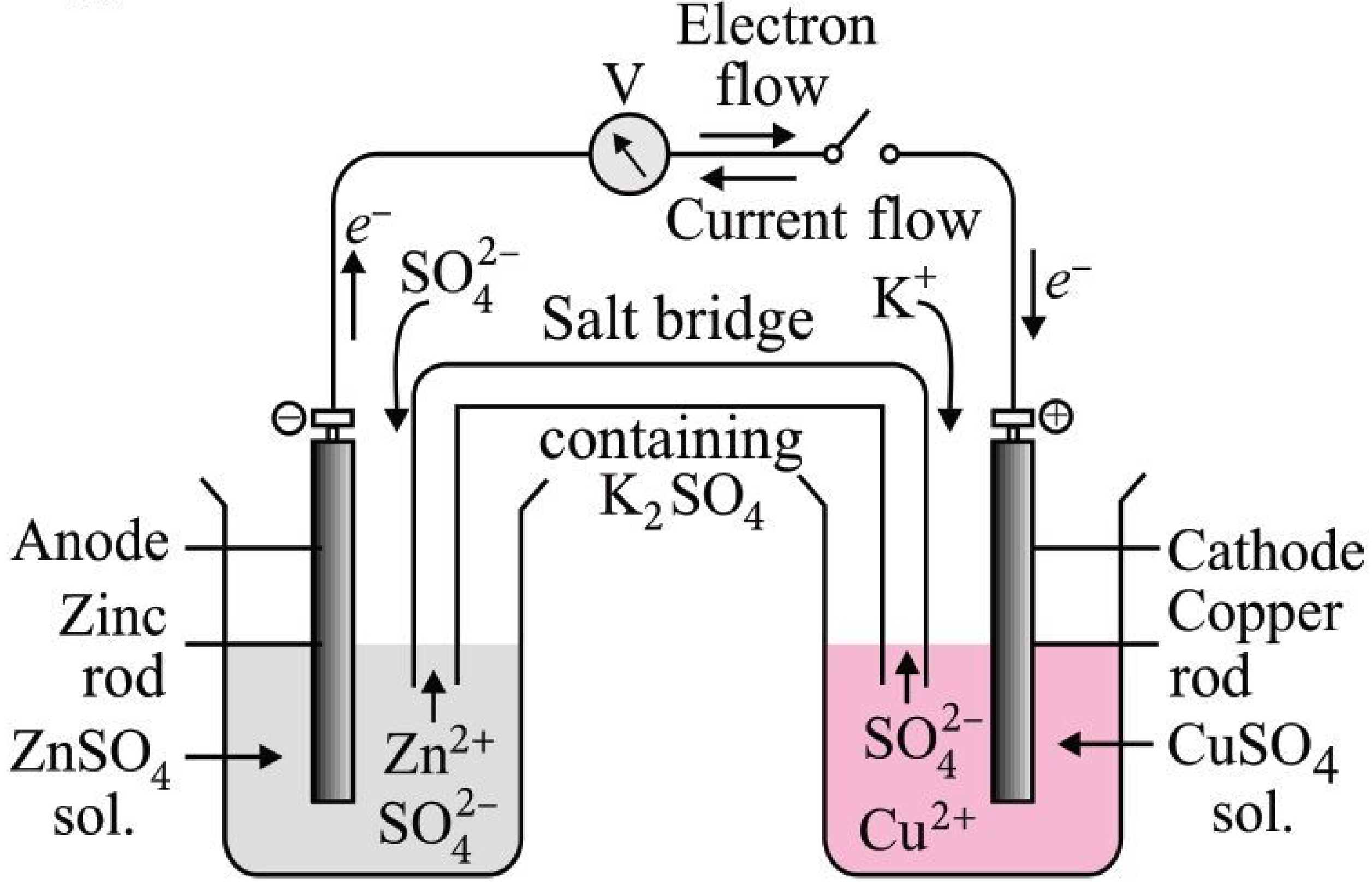
  Step 5 : Balance hydrogen and oxygen :
  - **Acidic medium:** Add H_2O to balance O and then add H^+ to balance H.
  - **Basic medium:** Add OH^- to balance charge and then add H_2O to balance H and O.
- **Half reaction method :**
  - Write down the reaction in ionic form.
  - Separate the equation into two half reactions.
  - Balance the atoms other than O and H in each half reaction individually.
  - For reactions occurring in acidic medium, add H_2O to balance O atoms and H^+ to balance H atoms and for basic medium, H atoms are balanced by adding H_2O molecule to the side deficient in H atoms and double number of OH^- ions are added to opposite side.
  - Add electrons to one side of the half reaction to balance the charge and make the number of electrons equal in two half reactions by multiplying one or both half reactions by appropriate number.
  - Add two half reactions to achieve the overall reaction and cancel the electrons on both sides.

Redox Titrations

- The method used to determine the strength of a reductant/oxidant using a redox sensitive indicators.
  - If the reagent itself is intensely coloured *e.g.*, MnO_4^-, it can act as self indicator.
  - If there is no auto-colour change, there are indicators which are oxidised immediately after the last drop of the reactant has reacted, producing a dramatic colour change *e.g.*, $Cr_2O_7^{2-}$ oxidises the indicator substance diphenylamine just after the equivalence point to produce an intense blue colour, thus signalling the end point.
  - Starch is used as indicator in case of those reagents which can either oxidise I^- ions such as Cu^{2+} or reduce I_2 such as $S_2O_3^{2-}$ ions as it gives intense blue colour with molecular iodine.

Redox Reactions and Electrode Processes

- **Redox couple :** It is defined as having together the oxidised and reduced forms of a substance taking part in an oxidation or reduction half reaction and is represented as Zn^{2+}/Zn and Cu^{2+}/Cu *i.e.*, a metal dipped in the solution of its own ions.



Set-up for Daniell cell

- **Salt bridge :** It completes the circuit and used to maintain electrical neutrality.
- **Electrode potential :** The potential difference set up between the metal and its own ions in the solution is called electrode potential. In general, it is the tendency of an electrode to gain or lose electrons.
- **Standard electrode potential ($E°$) :** If the concentration of each species taking part in the electrode reaction is unity and the reaction is carried out at 298 K, then the potential of each electrode is called standard electrode potential.
  - Standard electrode potential of hydrogen is taken as 0.00 volts by convention.
  - **Electrochemical series** is a series in which a list of oxidising agents are arranged in decreasing order of their strength. It is also called **activity** or **electromotive series**.
  - A negative $E°$ means that the redox couple is a stronger reducing agent than the H^+/H_2 couple.
  - A positive $E°$ means that the redox couple is a weaker reducing agent than the H^+/H_2 couple.

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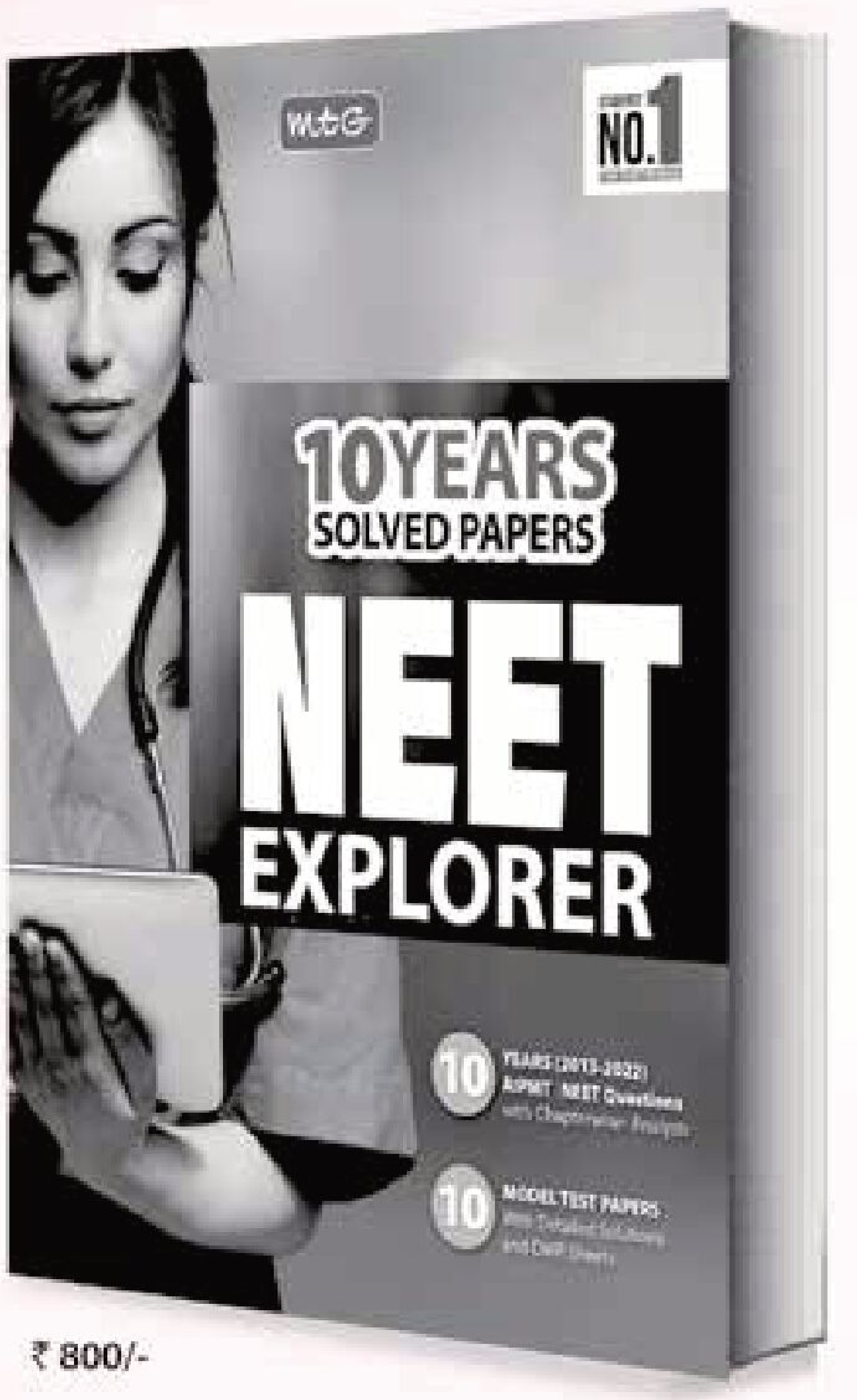

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HYDROGEN

DIHYDROGEN, H_2

- Hydrogen is the first element in the periodic table and its position in the periodic table is anomalous.

Isotopes

- The three isotopes of hydrogen are protium (^1_1H), deuterium (^2_1H) and tritium (^3_1H).

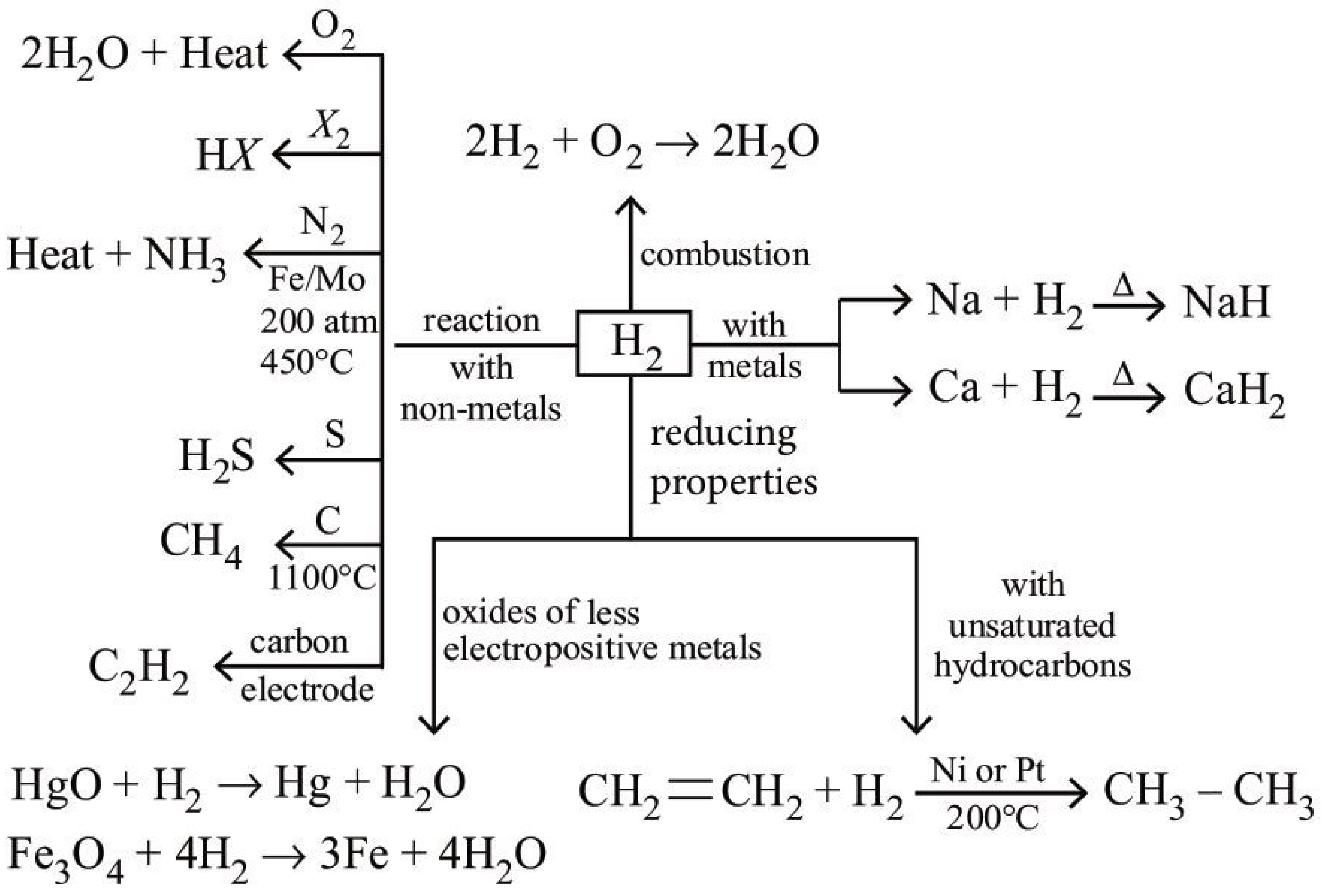
Preparation of Dihydrogen

- **By the action of water on metals :**
  $2Na + 2H_2O \longrightarrow 2NaOH + H_2$
- **By the action of water on ionic hydrides :**
  $NaH + H_2O \longrightarrow NaOH + H_2$
- **Bosch's process :** $\underset{\text{(Steam)}}{C + H_2O} \xrightarrow[\text{Ni}]{1000°C} \underbrace{CO + H_2}_{\text{Water gas}}$
- **From acids :** (Active metals which lie above hydrogen in the electrochemical series)
  $Zn + H_2SO_{4(dil.)} \longrightarrow ZnSO_4 + H_2$
- **Lane's Process :** $3Fe + \underset{\text{(Steam)}}{4H_2O} \xrightleftharpoons{773-1050\ K} Fe_3O_4 + 4H_2$

Physical Properties

- It is a colourless, tasteless and odourless gas.
- It is slightly soluble in water.
- It is the lightest substance known.

Chemical Properties


$2H_2O$ + Heat
O_2
HX
X_2
Heat + NH_3
N_2
Fe/Mo
200 atm
450°C
H_2S
S
CH_4
C
1100°C
C_2H_2
carbon
electrode
$2H_2 + O_2 \rightarrow 2H_2O$
combustion
reaction
with
non-metals
H_2
with
metals
$Na + H_2 \xrightarrow{\Delta} NaH$
$Ca + H_2 \xrightarrow{\Delta} CaH_2$
reducing
properties
oxides of less
electropositive metals
with
unsaturated
hydrocarbons
$HgO + H_2 \rightarrow Hg + H_2O$
$Fe_3O_4 + 4H_2 \rightarrow 3Fe + 4H_2O$
$CH_2{=}CH_2 + H_2 \xrightarrow[200°C]{\text{Ni or Pt}} CH_3 - CH_3$

Uses

- Used as a reducing agent in industry and laboratories.
- Used to prepare hydrogenated vegetable solid fats.
- Used for welding purposes in both the oxy-hydrogen torch and the atomic-hydrogen torch.

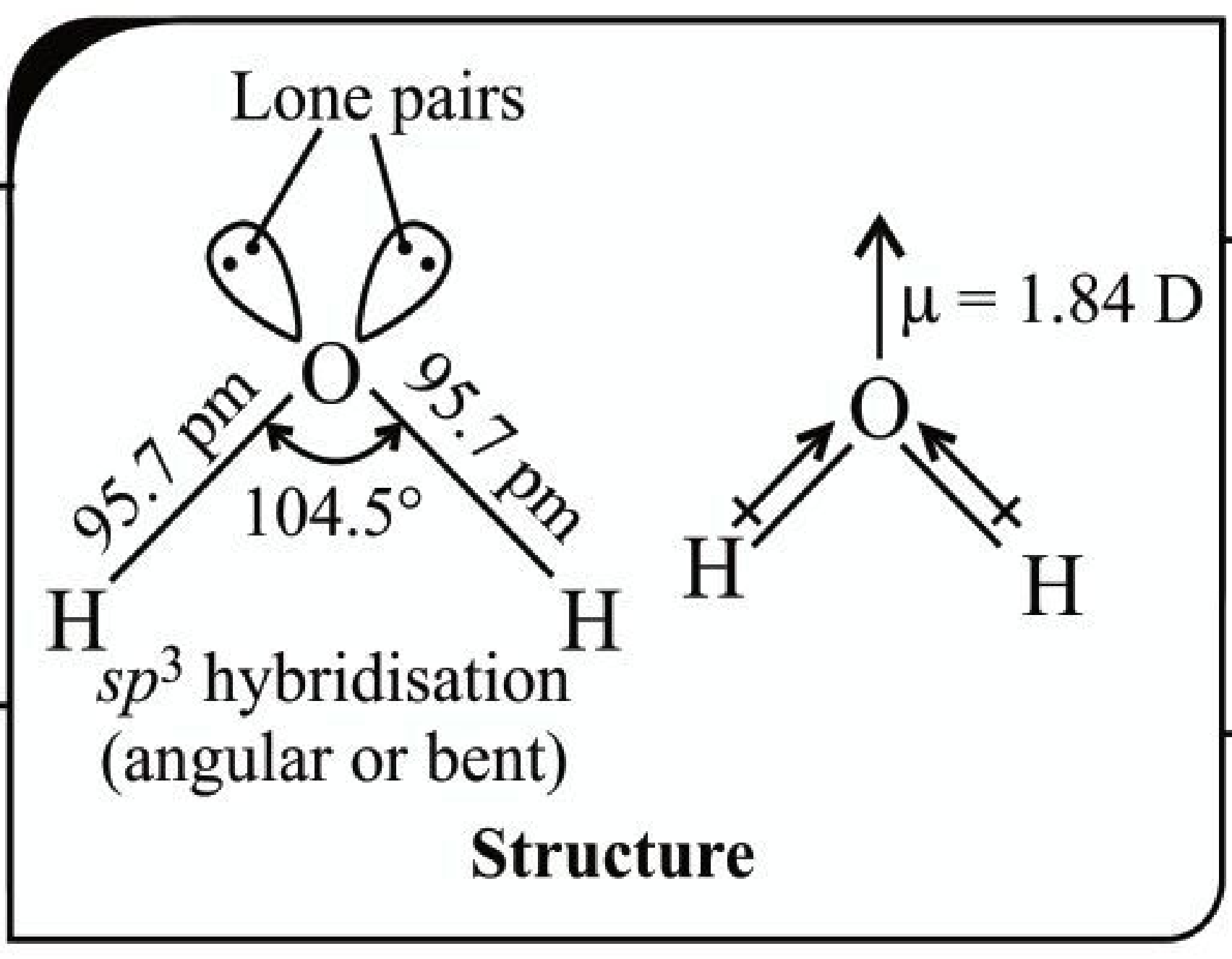
HYDRIDES

Ionic, saline or salt like hydrides	Molecular or covalent hydrides	Metallic or interstitial hydrides
They are formed by *s*-block elements (highly electropositive), except Be and Mg which form polymeric hydrides.	They are formed by highly electronegative elements (like non-metals) which share electrons with hydrogen.	They are formed by transition and inner-transition elements.
These are solids with ionic lattices and behave like salts.	In these, molecules are held together by van der Waals forces.	In these, the hydrogen atoms occupy some of the holes in the metal lattices.
They have hydrogen as anion. $2Na + H_2 \longrightarrow \underset{\text{Sod. hydride}}{2NaH}$	They have low melting point, boiling point and electrical conductivity.	These are non-stoichiometric compounds ($TiH_{1.73}$, $PdH_{0.6\text{-}0.8}$, $VH_{0.56}$) and give out hydrogen easily.
They have high melting point, boiling point and density.	$\xrightarrow[\text{Stability and acidic nature increases (in period)}]{CH_4 < NH_3 < H_2O < HF}$	They act as strong reducing agents and have high conductivity.
The thermal stability decreases with increasing size of cations. – LiH > NaH > KH > RbH > CsH – $CaH_2 > SrH_2 > BaH_2$	$\xrightarrow[\text{Stability decreases (in group)}]{NH_3 > PH_3 > AsH_3 > SbH_3 > BiH_3}$	These hydrides are used for the ultrapurification of hydrogen and as hydrogen storage media.

WATER, H_2O

Colourless, odourless and tasteless liquid.

Plays a key role in the biosphere due to its high specific heat, thermal conductivity, surface tension, dipole moment and dielectric constant, etc.



Extensive hydrogen bonding leads to high freezing point, high boiling point, high heat of vaporisation and high heat of fusion in comparison to H_2S and H_2Se.

Water has maximum density at 277 K as above this temperature, the increase in volume due to expansion of liquid water is much more than the decrease in volume due to breaking of H-bonds.

Hydrogen Bonding in Water and Ice

- In the liquid state, each water molecule is generally H-bonded to four other water molecules. Thus, in liquid state, H_2O exists as an associated liquid.
- In the normal hexagonal ice, each oxygen atom is tetrahedrally surrounded by four other oxygen atoms, *i.e.*, there is a hydrogen atom between each pair of oxygen atoms. This gives ice an open cage-like structure.

Chemical Properties

- **Self-ionisation of water :**

$$H_2O_{(l)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$$

- **Amphoteric character :**

$$\underset{\text{Base}}{H_2O_{(l)}} + \underset{\text{Acid}}{HCl_{(aq)}} \rightleftharpoons \underset{\text{Acid}}{H_3O^+_{(aq)}} + \underset{\text{Base}}{Cl^-_{(aq)}}$$

$$\underset{\text{Acid}}{H_2O_{(l)}} + \underset{\text{Base}}{NH_{3(aq)}} \rightleftharpoons \underset{\text{Acid}}{NH^+_{4(aq)}} + \underset{\text{Base}}{OH^-_{(aq)}}$$

- **As an oxidising agent :**

Reduction

$$2Na_{(s)} + 2H_2O_{(l)} \longrightarrow 2NaOH + H_{2(g)}$$

Oxidation

- **As a reducing agent :**

$$nCO_{2(g)} + nH_2O_{(l)} \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \underset{\text{Carbohydrate}}{(CH_2O)_n} + O_{2(g)}$$

HEAVY WATER

- Chemically, heavy water is deuterium oxide (D_2O).
- Ordinary water contains traces of D_2O.

Preparation of Heavy Water

- By prolonged electrolysis of H_2O.
- By fractional distillation of H_2O.

Physical Properties

- Heavy water is colourless, tasteless and odourless liquid.
- It has all higher values for physical constant than the corresponding values of ordinary water.

Chemical Properties

$$D_2O \xrightarrow{Na_2O} NaOD$$
$$D_2O \xrightarrow{CaO} Ca(OD)_2$$
$$D_2O \xrightarrow{N_2O_5} DNO_3 \text{ (Deuteronitric acid)}$$
$$D_2O \xrightarrow{SO_3} D_2SO_4 \text{ (Deuterosulphuric acid)}$$
$$D_2O \xrightarrow{P_2O_5} D_3PO_4 \text{ (Deuterophosphoric acid)}$$
$$D_2O \xrightarrow{CaC_2} Ca(OD)_2 + DC{\equiv}CD \text{ (Deuteroacetylene)}$$
$$D_2O \xrightarrow{Al_4C_3} Al(OD)_3 + CD_4 \text{ (Deuteromethane)}$$
$$D_2O \xrightarrow{Ca_3P_2} Ca(OD)_2 + PD_3 \text{ (Deuterophosphine)}$$
$$D_2O \xrightarrow{Mg_3N_2} Mg(OD)_2 + ND_3 \text{ (Deuteroammonia)}$$
$$D_2O \xrightarrow{NaOH} NaOD + HDO$$
$$D_2O \xrightarrow{HCl} DCl + HDO$$

Uses

- D_2O is used as a neutron moderator.
- In the preparation of deuterium and as a tracer compound.

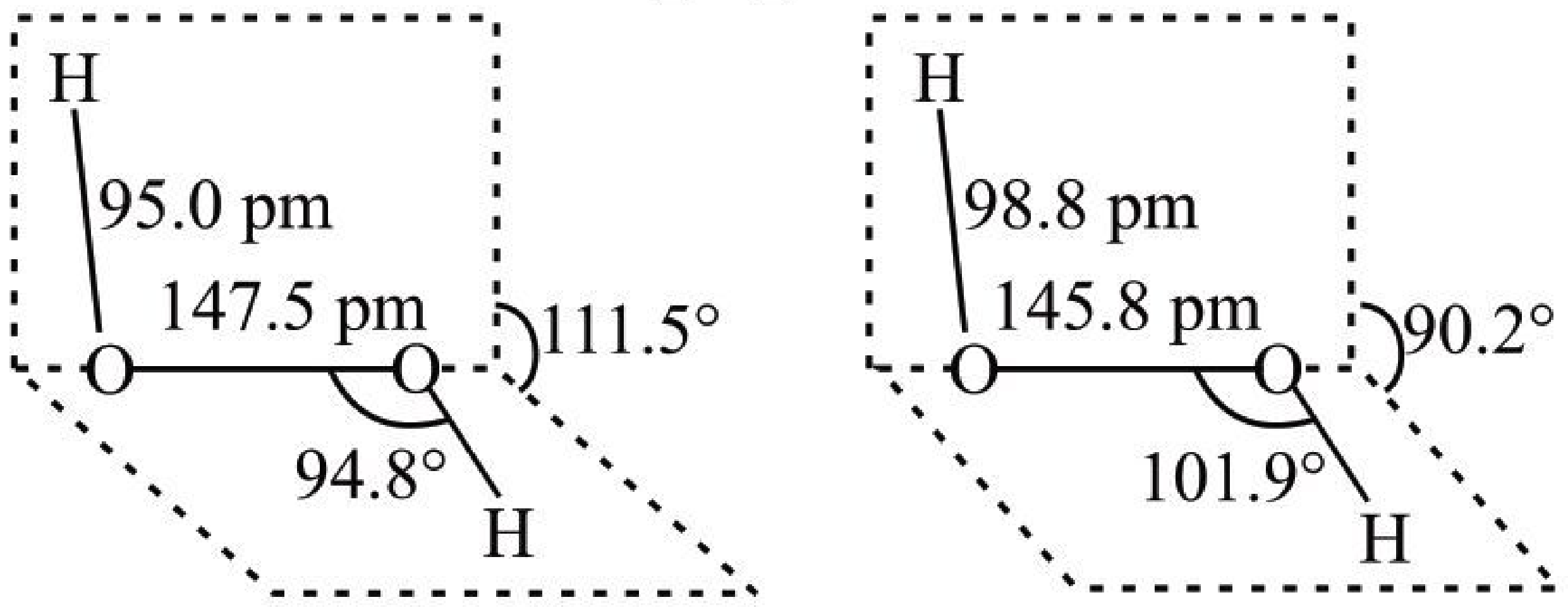
HARDNESS OF WATER

Temporary hardness	Permanent hardness
It is due to the presence of bicarbonates of calcium and magnesium.	It is due to the presence of soluble chlorides and sulphates of calcium and magnesium.
It can be easily removed by boiling or by Clark's process (using quick lime).	It can be removed by special methods like washing soda method, ion-exchange method and Calgon's process.

HYDROGEN PEROXIDE, H_2O_2

- Pure H_2O_2 is an almost colourless (very pale blue) liquid.
- H_2O_2 is miscible in water in all proportions and forms a hydrate $H_2O_2 \cdot H_2O$.

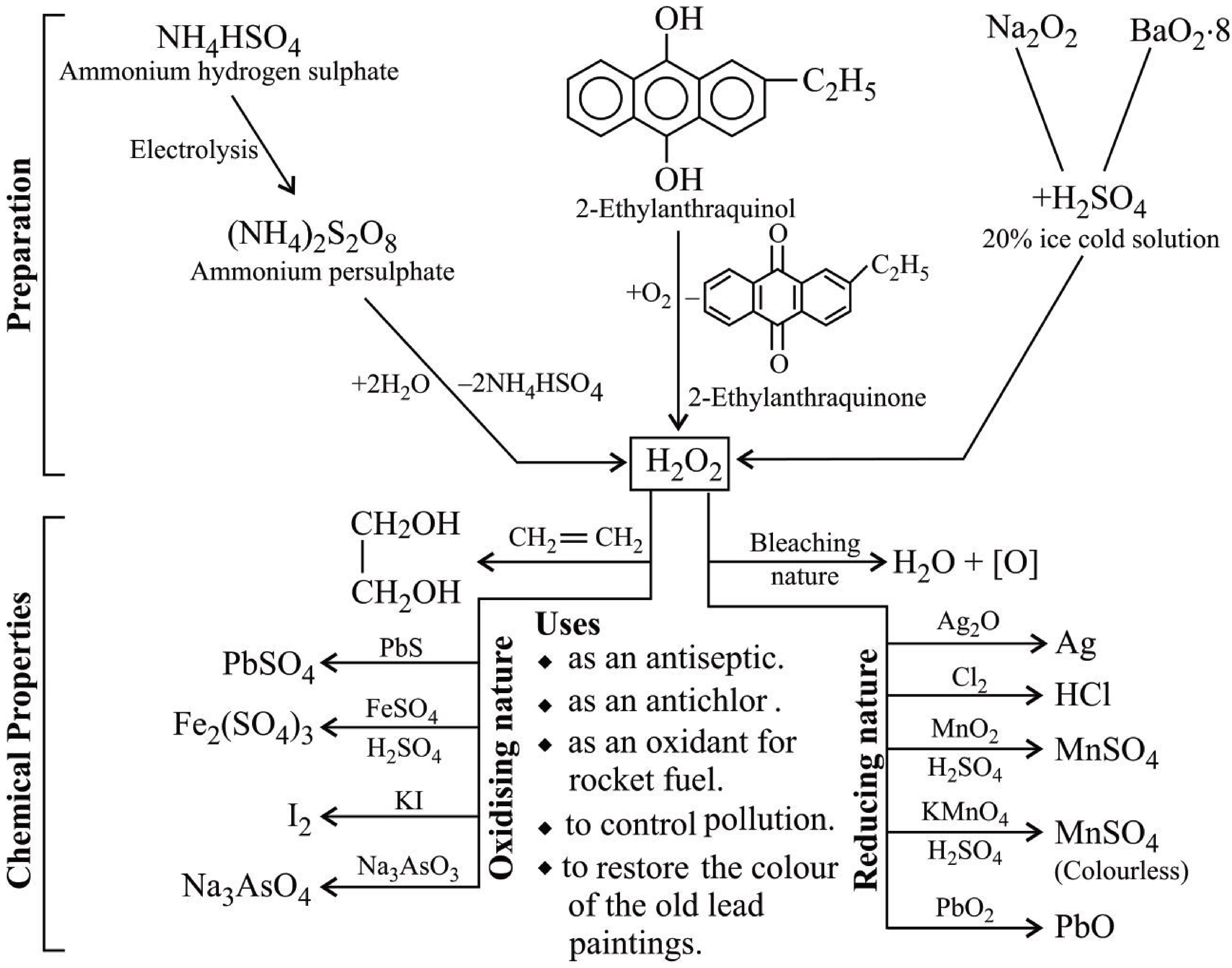
Structures of H_2O_2


H
95.0 pm
147.5 pm
111.5°
O
O
94.8°
H
H
98.8 pm
145.8 pm
90.2°
O
O
101.9°
H

Gas phase

Solid phase

Preparation and Properties of H_2O_2


Preparation
NH4HSO4
Ammonium hydrogen sulphate
Electrolysis
(NH4)2S2O8
Ammonium persulphate
+2H2O
−2NH4HSO4
OH
C2H5
OH
2-Ethylanthraquinol
+O2
O
C2H5
O
2-Ethylanthraquinone
Na2O2
BaO2·8H2O
+H2SO4
20% ice cold solution
H2O2
Chemical Properties
CH2OH
CH2OH
CH2=CH2
Bleaching nature
H2O + [O]
PbSO4
PbS
Fe2(SO4)3
FeSO4
H2SO4
I2
KI
Na3AsO4
Na3AsO3
Oxidising nature
Uses
◆ as an antiseptic.
◆ as an antichlor.
◆ as an oxidant for rocket fuel.
◆ to control pollution.
◆ to restore the colour of the old lead paintings.
Reducing nature
Ag2O
Ag
Cl2
HCl
MnO2
H2SO4
MnSO4
KMnO4
H2SO4
MnSO4
(Colourless)
PbO2
PbO

WRAP it up!

MCQs TYPE QUESTIONS

1. The oxidation state of sulphur in the anions SO_3^{2-}, SO_4^{2-}, $S_2O_4^{2-}$, $S_2O_6^{2-}$ is in the order of
   (a) $S_2O_4^{2-} > S_2O_6^{2-} > SO_4^{2-} > SO_3^{2-}$
   (b) $S_2O_6^{2-} > SO_3^{2-} > S_2O_4^{2-} > SO_4^{2-}$
   (c) $SO_4^{2-} > S_2O_6^{2-} > SO_3^{2-} > S_2O_4^{2-}$
   (d) $SO_3^{2-} > SO_4^{2-} > S_2O_4^{2-} > S_2O_6^{2-}$
2. In which of the following reactions, hydrogen peroxide acts as an oxidizing agent?
   (a) $I_2 + H_2O_2 + 2OH^- \rightarrow 2I^- + 2H_2O + O_2$
   (b) $PbS + 4H_2O_2 \rightarrow PbSO_4 + 4H_2O$
   (c) $2MnO_4^- + 3H_2O_2 \rightarrow 2MnO_2 + 3O_2 + 2H_2O + 2OH^-$
   (d) $HOCl + H_2O_2 \rightarrow H_3O^+ + Cl^- + O_2$
3. Oxidation number of potassium in K_2O, K_2O_2 and KO_2, respectively, is
   (a) +1, +1 and +1
   (b) +2, +1 and $+\frac{1}{2}$
   (c) +1, +2 and +4
   (d) +1, +4 and +2.
4. Which of the following chemical reactions depicts the oxidising behaviour of H_2SO_4?
   (a) $2HI + H_2SO_4 \rightarrow I_2 + SO_2 + 2H_2O$
   (b) $Ca(OH)_2 + H_2SO_4 \rightarrow CaSO_4 + 2H_2O$

(c) $NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$
(d) $2PCl_5 + H_2SO_4 \rightarrow 2POCl_3 + 2HCl + SO_2Cl_2$

5. The compound that cannot act both as oxidising and reducing agent is
(a) H_2SO_3 (b) H_3PO_4 (c) HNO_2 (d) H_2O_2

6. **Assertion :** Hydrides of group 13 elements are Lewis acids whereas hydrides of group 15-17 elements are Lewis bases.
Reason : Group 13 hydrides have few electrons whereas group 15-17 hydrides have excess electrons which are present as lone pairs.
(a) Both assertion and reason are true and reason is the correct explanation of assertion.
(b) Both assertion and reason are true but reason is not the correct explanation of assertion.
(c) Assertion is true but reason is false.
(d) Both assertion and reason are false.

7. **Assertion :** In the reaction,
$2Cu_2O_{(s)} + Cu_2S_{(s)} \rightarrow 6Cu_{(s)} + SO_{2(g)}$
copper acts as a reductant and sulphur acts as an oxidant.
Reason : The given reaction is not a redox reaction.
(a) Both assertion and reason are true and reason is the correct explanation of assertion.
(b) Both assertion and reason are true but reason is not the correct explanation of assertion.
(c) Assertion is true but reason is false.
(d) Both assertion and reason are false.

8. Which of the following is not a property of hydrogen?
(a) It is a colourless, odourless gas.
(b) It is highly combustible.
(c) It is highly poisonous gas.
(d) It is lighter than air.

9. Dihydrogen forms three types of hydrides. (i) hydrides are formed by alkali metals and alkaline earth metals. (ii) hydrides are formed by non-metals and (iii) hydrides are formed by *d* and *f*-block elements at elevated temperature. Complex metal hydrides such as (iv) and (v) are powerful reducing agents.

	(i)	(ii)	(iii)	(iv)	(v)
(a)	Covalent	Molecular	Saline	NaH	LiH
(b)	Molecular	Covalent	Ionic	$LiAlH_4$	CaH_2
(c)	Ionic	Covalent	Interstitial	$LiAlH_4$	$NaBH_4$
(d)	Covalent	Saline	Interstitial	$LiAlH_4$	$NaBH_4$

10. Which of the following is a laboratory preparation of dihydrogen?
(a) $3Fe + 4H_2O$ (steam) $\rightarrow Fe_3O_4 + 4H_2$
(b) $2Na + 2H_2O \rightarrow 2NaOH + H_2$
(c) $CaH_2 + 2H_2O \rightarrow Ca(OH)_2 + 2H_2$
(d) $Zn + H_2SO_4(\text{dil.}) \rightarrow ZnSO_4 + H_2$

11. What is the oxidation number of gold in the complex $[AuCl_4]^-$?
(a) +4 (b) +3 (c) +2 (d) +1

12. What is the main product formed when iodine reacts with hypo?
(a) Na_2SO_4 (b) $Na_2S_4O_6$
(c) Na_2SO_3 (d) Na_2S

13. Strongest reducing agent among the following is
(i) $Na^+ + e^- \longrightarrow Na_{(s)}$; $E° = -2.71$ V
(ii) $Al^{3+} + 3e^- \longrightarrow Al_{(s)}$; $E° = -1.66$ V
(iii) $F_{2(g)} + 2e^- \longrightarrow 2F^-$; $E° = +2.87$ V
(iv) $2H_2O + 2e^- \longrightarrow H_{2(g)} + 2OH^-_{(aq)}$; $E° = -0.83$ V
(a) (iv) (b) (iii) (c) (ii) (d) (i)

14. The number of moles of electron required to reduce 0.2 mole of $Cr_2O_7^{2-}$ to Cr^{3+}
(a) 1.2 (b) 6 (c) 12 (d) 0.6

15. Which of the following statements is not correct?
(a) H_2O_2 reduces Mn(VII) to Mn(II).
(b) H_2O_2 can be obtained by electrolysis of dil. H_2SO_4.
(c) H_2O_2 oxidises Fe(II) to Fe(III).
(d) H_2O_2 is a weak base.

16. Permanent hardness is due to presence of soluble salts of magnesium and calcium in the form of chlorides and sulphates in water. Permanent hardness of water can be removed by
(a) boiling
(b) Clark's method
(c) treatment with sodium carbonate
(d) treatment with 2-ethylanthraquinol in the presence of air.

17. Heavy water is manufactured
(a) by combination of hydrogen and heavier isotope of oxygen
(b) by electrolysis of water containing heavy hydrogen dissolved in it
(c) by repeated electrolysis of 3% aqueous solution of NaOH
(d) none of these.

18. Among CaH_2, NH_3, NaH and B_2H_6, which are covalent hydrides?
(a) NH_3 and B_2H_6 (b) NaH and CaH_2
(c) NaH and NH_3 (d) CaH_2 and B_2H_6

19. Hydrogen has three isotopes, the radioactive isotope has the mass number
(a) 3 (b) 6 (c) 2 (d) 1

20. On burning hydrogen in air the colour of flame is
(a) green (b) light bluish
(c) yellow (d) none of these.

NUMERICAL VALUE TYPE QUESTIONS

21. The number of hydrogen bonded water molecules associated with copper ion in $CuSO_4 \cdot 5H_2O$ is ______.

22. The hardness of a water sample containing 10^{-3} M $MgSO_4$ expressed as $CaCO_3$ equivalents (in ppm) is ______. (Molar mass of $MgSO_4$ is 120.37 g/mol)

23. The volume (in mL) of 0.02 M $K_2Cr_2O_7$ solution required to react with 0.288 g of ferrous oxalate in acidic medium is ______.
(Molar mass of Fe = 56 g mol^{-1})

24. The volume strength of 8.9 M H_2O_2 solution calculated at 273 K and 1 atm is ______.
(R = 0.0821 L atm K^{-1} mol^{-1}) (rounded off to the nearest integer)

25. A 20.0 mL solution containing 0.2 g impure H_2O_2 reacts completely with 0.316 g of $KMnO_4$ in acid solution. The purity of H_2O_2 (in %) is ______.
(mol. wt. of H_2O_2 = 34; mol. wt. of $KMnO_4$ = 158)

Solutions

1. **(c)**

2. **(b):** $\overset{+2-2}{PbS} + 4H_2\overset{-1}{O_2} \longrightarrow \overset{+2+6}{PbSO_4} + 4H_2\overset{-2}{O}$

Gain of electrons

Since, H_2O_2 gains electron to convert into H_2O, hence, H_2O_2 acts as an oxidising agent.

3. **(a):** For K_2O : $2x - 2 = 0 \Rightarrow x = +1$
For K_2O_2 : $2x - 2 = 0 \Rightarrow x = +1$
(In peroxide, the O.S. of oxygen is −1.)
For KO_2 : $x - 2 \times \frac{1}{2} = 0 \Rightarrow x = +1$
(In superoxide, the O.S. of oxygen is $-\frac{1}{2}$.)

4. **(a)**

5. **(b):** In H_3PO_4, oxidation state of 'P' is +5 which is maximum. Hence, it cannot act as an oxidising agent.

6. **(a)**

7. **(d):** The oxidation states are as :

$$2\overset{+1\ -2}{Cu_2O_{(s)}} + \overset{+1\ -2}{Cu_2S_{(s)}} \rightarrow 6\overset{0}{Cu_{(s)}} + \overset{+4-2}{SO_{2(g)}}$$

Copper is reduced from +1 state to zero. Sulphur is oxidised from −2 state to +4. Cu_2O helps sulphur in Cu_2S to increase its oxidation number, hence Cu(I) is an oxidant and sulphur of Cu_2S helps copper both in Cu_2S itself and Cu_2O to decrease its oxidation number, hence S of Cu_2S is a reductant. And the reaction is redox reaction.

8. **(c):** It is a non-poisonous gas.

9. **(c)** **10.** **(d)**

11. **(b):** Let x be the oxidation number of gold (Au) in $[AuCl_4]^-$.
$x + 4(-1) = -1$
$x - 4 = -1 \Rightarrow x = -1 + 4 = +3$

12. **(b):** $\underset{\text{Hypo}}{2Na_2S_2O_3} + I_2 \longrightarrow Na_2S_4O_6 + 2NaI$

13. **(d):** Lower the $E°$ value (more negative), stronger is the reducing agent.

14. **(a)**

15. **(d):** H_2O_2 is not a weak base but a weak acid.

16. **(c)**

17. **(c):** Heavy water is manufactured by repeated electrolysis of water (containing a little NaOH).

18. **(a):** Non-metal hydrides are covalent hydrides.

19. **(a)** **20.** **(b)** **21.** **(4)**

22. **(100):** $\text{ppm} = \dfrac{\text{Mass of component}}{\text{Total mass of solution}} \times 10^6$

Molecular mass of $CaCO_3$ = 40 + 12 + 48 = 100

10^{-3} moles $MgSO_4$ = 10^{-3} moles of $CaCO_3$ in 1L solution

Thus, $\text{ppm } (CaCO_3) = \dfrac{10^{-3} \times 100}{1000} \times 10^6 = 100 \text{ ppm}$

23. **(50)**

24. **(100):** Volume strength of H_2O_2 at 273 K and 1 atm = 11.2 × molarity = 11.2 × 8.9 = 99.68 ≈ 100

25. **(85):** Reaction of H_2O_2 with $KMnO_4$ in acidic medium is

$$3H_2SO_4 + KMnO_4 + 5H_2O_2 \longrightarrow 5O_2 + 2MnSO_4 + 8H_2O + K_2SO_4$$

Valency factor for H_2O_2 = 2
Valency factor for $KMnO_4$ = 5

$$\left[\frac{x}{34}\right] \times 2 = \frac{0.316}{158} \times 5\ ;\ x = \frac{0.316 \times 5 \times 34}{158 \times 2} = 0.17\,\text{g}$$

$$\%\ \text{Purity} = \frac{\text{Weight of pure substance}}{\text{Weight of given sample}} \times 100$$

$$= \frac{0.17}{0.2} \times 100 = 85\%$$

◆ ◆

MONTHLY TEST DRIVE

XI

This specially designed column enables students to self analyse their extent of understanding the specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Total Marks : 120

Hydrocarbons | Environmental Chemistry

Time Taken : 60 Min.

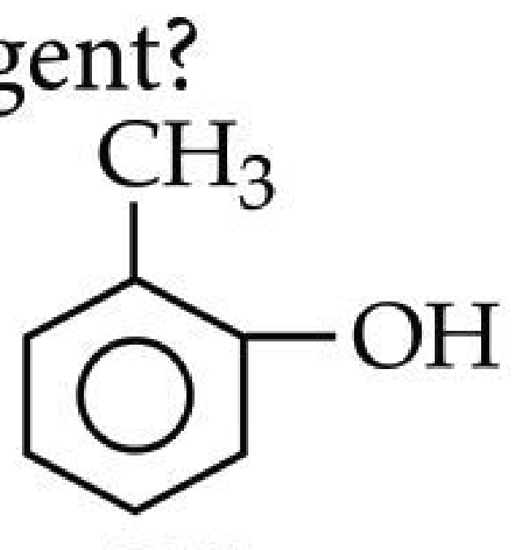
NEET

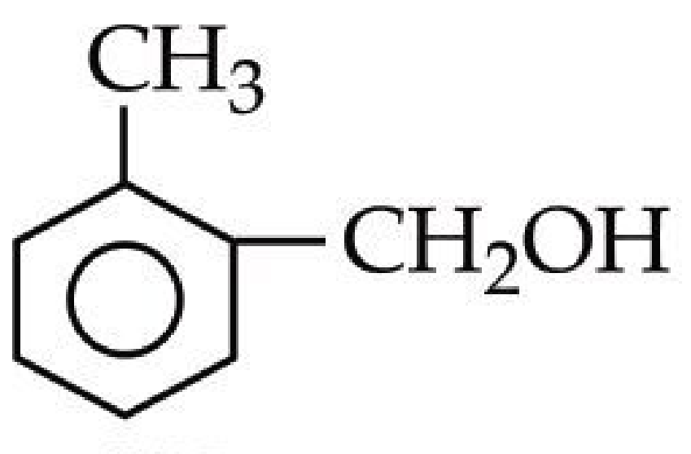
Only One Option Correct Type

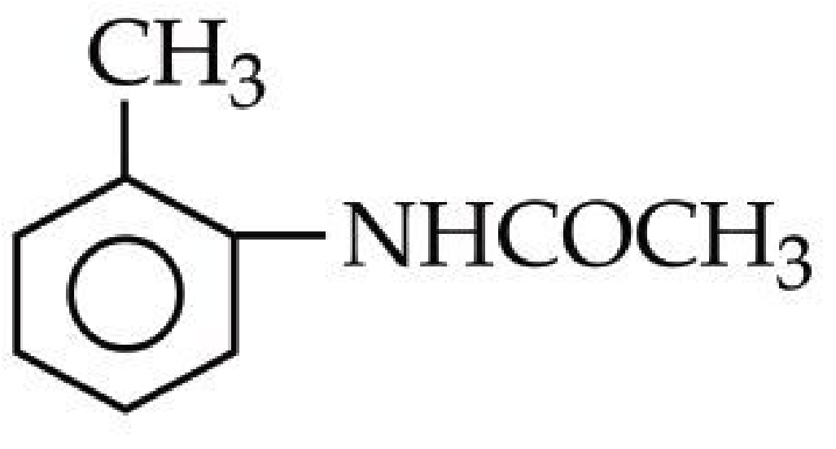
1. When propyne is treated with aqueous H_2SO_4 in presence of $HgSO_4$, the major product is
(a) propanal
(b) propyl hydrogen sulphate
(c) acetone
(d) propanol.

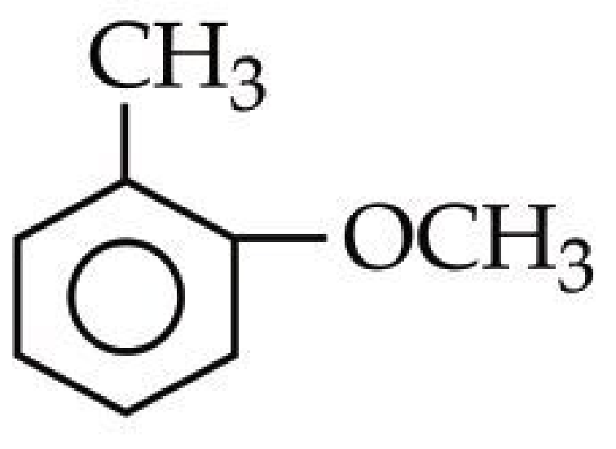
2. Which one of the following gases is reported to retard photosynthesis?
(a) CFCs (b) CO (c) NO_2 (d) CO_2

3. Which is the most reactive towards electrophilic reagent?

(a) 

(b) 

(c) 

(d) 

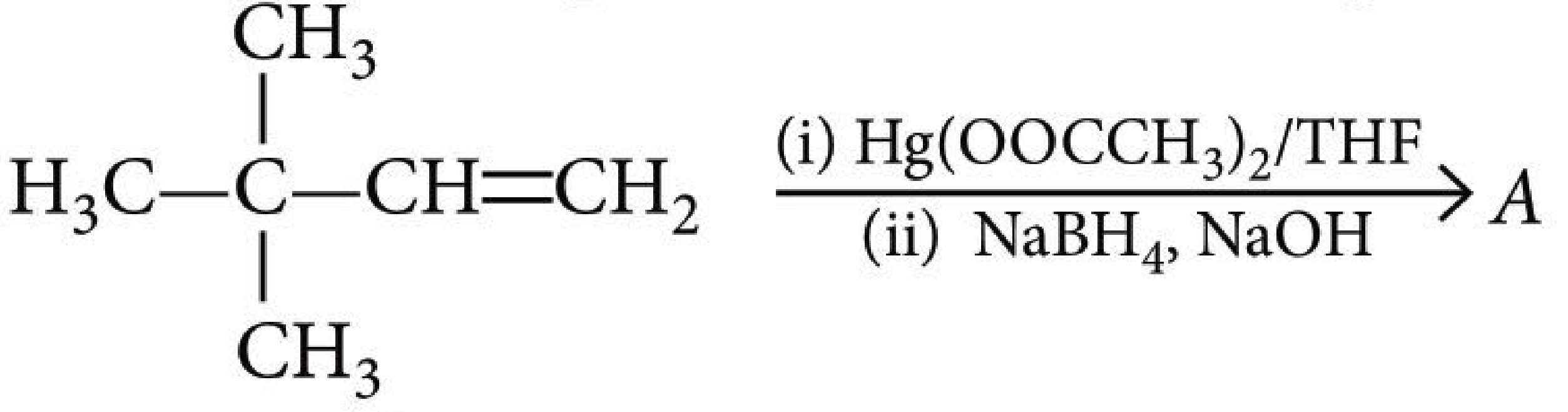
4. Photochemical smog is formed in
(a) summer during day time
(b) summer during night time
(c) winter during morning time
(d) winter during day time.

5. Methane can be converted into ethane by the reactions
(a) chlorination followed by the reaction with alcoholic KOH
(b) chlorination followed by the reaction with aqueous KOH
(c) chlorination followed by Wurtz reaction
(d) chlorination followed by decarboxylation.

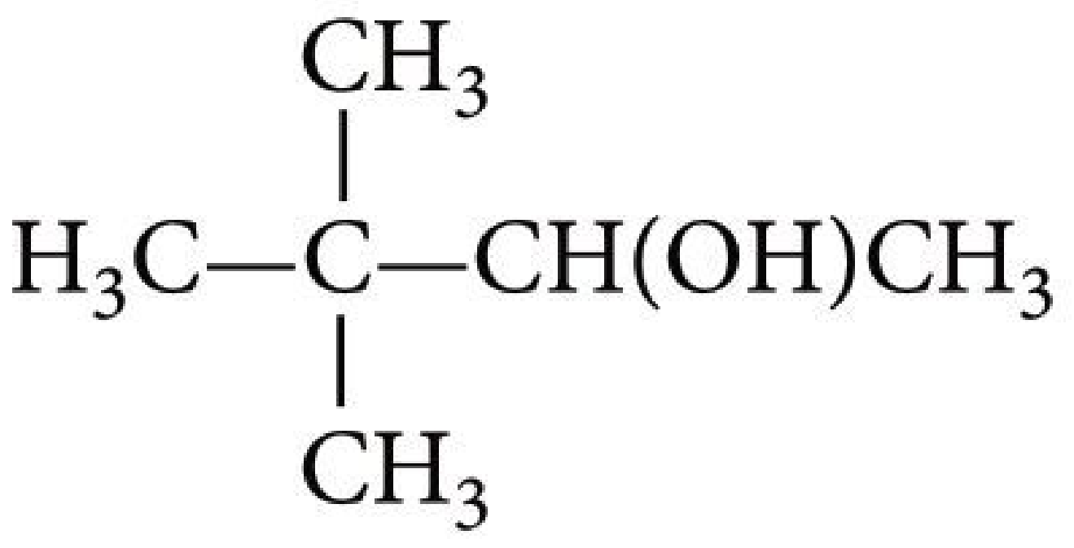
6. Carbon monoxide is harmful to human beings as it
(a) is carcinogenic
(b) is antagonistic to CO_2
(c) has higher affinity for haemoglobin as compared to oxygen
(d) is destructive to CO_2.

7. Acid rains are produced by
(a) excess NO_2 and SO_2 from burning fossil fuels
(b) excess production of NH_3 by industry and coal gas
(c) excess release of carbon monoxide by incomplete combustion
(d) excess formation of CO_2 by combustion and animal respiration.

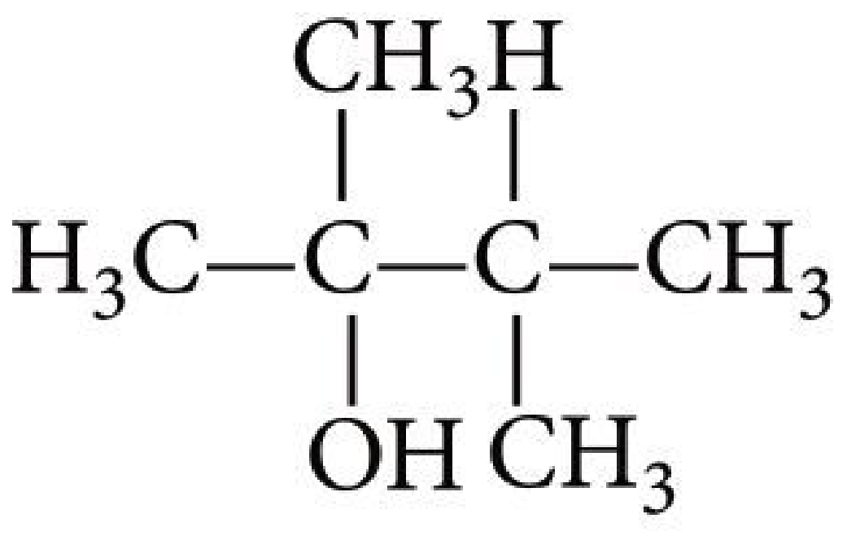
8. What will be compound *A* in the following reaction?



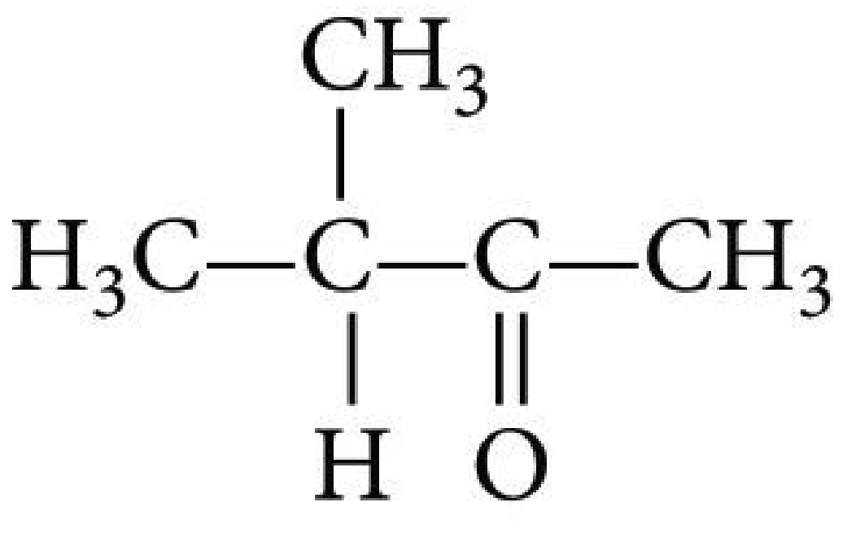
$$H_3C-\underset{CH_3}{\overset{CH_3}{C}}-CH=CH_2 \xrightarrow[\text{(ii) NaBH}_4\text{, NaOH}]{\text{(i) Hg(OOCCH}_3)_2\text{/THF}} A$$

(a) 

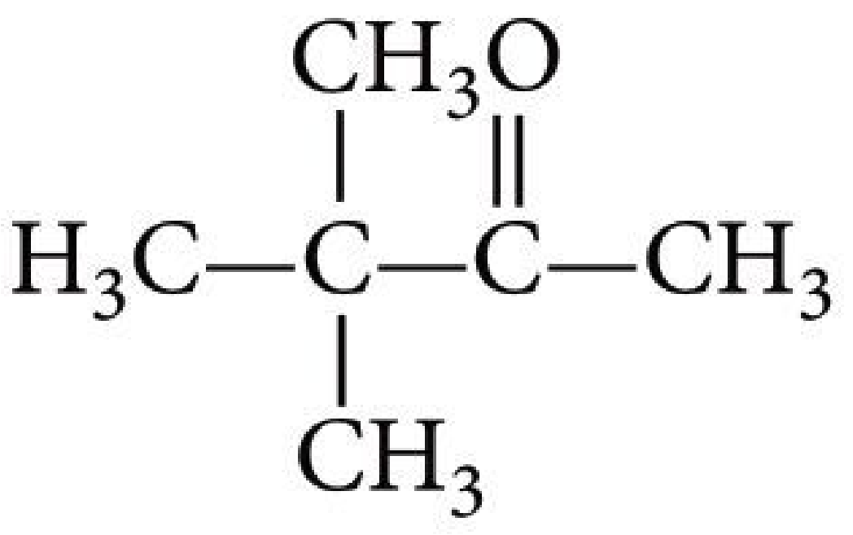
$H_3C-\underset{CH_3}{\overset{CH_3}{C}}-CH(OH)CH_3$

(b) 

$H_3C-\underset{OH}{\overset{CH_3}{C}}-\underset{CH_3}{\overset{H}{C}}-CH_3$

(c) 

$H_3C-\underset{H}{\overset{CH_3}{C}}-\underset{\underset{O}{\|}}{C}-CH_3$

(d) 

$H_3C-\underset{CH_3}{\overset{CH_3}{C}}-\overset{\overset{O}{\|}}{C}-CH_3$

9. The heat of hydrogenation of 1-hexene is 126 kJ mol^{-1}. When a second double bond is introduced in the molecule, the heat of hydrogenation of the resulting compound is 230 kJ mol^{-1}. The resulting compound (diene) is

(a) 1,3-Hexadiene

(b) 1,4-Hexadiene

(c) 1,5-Hexadiene

(d) cannot predict from the given information.

10. Eutrophication causes reduction in

(a) nutrients (b) dissolved salts

(c) dissolved oxygen (d) all of these.

11. In the chemical reaction,

$A \xrightarrow{O_3} B \xrightarrow{Zn+H_2O}$ Propan-2-one + methanal.

The compound A is

(a) 2-methylpropene (b) but-1-ene

(c) but-2-ene (d) 1, 3-butadiene.

12. Which of the following statements is not true?

(a) Ozone is not a greenhouse gas.

(b) Ozone can oxidise sulphur dioxide present in the atmosphere to sulphur trioxide.

(c) Ozone hole is thinning of ozone layer present in stratosphere.

(d) Ozone is produced in upper stratosphere by the action of UV rays on oxygen.

Assertion & Reason Type

Directions : In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :

(a) If both assertion and reason are true and reason is the correct explanation of assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of assertion.

(c) If assertion is true but reason is false.

(d) If both assertion and reason are false.

13. Assertion : COD is always greater than BOD.

Reason : COD measurement involves both organic and inorganic impurities.

14. Assertion : $HC\equiv C^-$ is more stable than $H_2C{=}CH^-$.

Reason : $HC\equiv C^-$ has less s-character than $H_2C{=}CH^-$.

15. Assertion : The pH of acid rain is less than 5.6.

Reason : Oxides of nitrogen and sulphur present in the atmosphere dissolves in rain water and form acid.

JEE MAIN / JEE ADVANCED

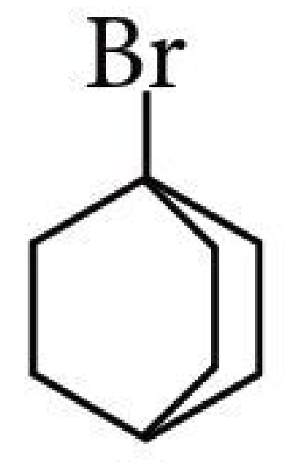
Only One Option Correct Type

16. What is the BOD value of a sewage sample containing 9.2 mg/L of organic matter with the formula $C_6H_{12}O_6$?

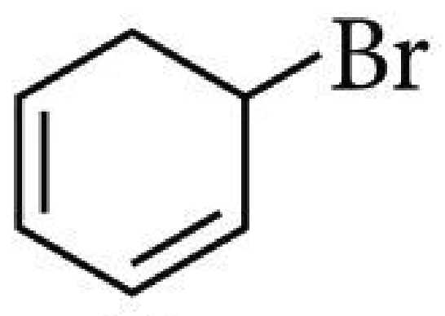
(a) 8.625 mg/L (b) 9.2 mg/L

(c) 11.594 mg/L (d) 9.813 mg/L

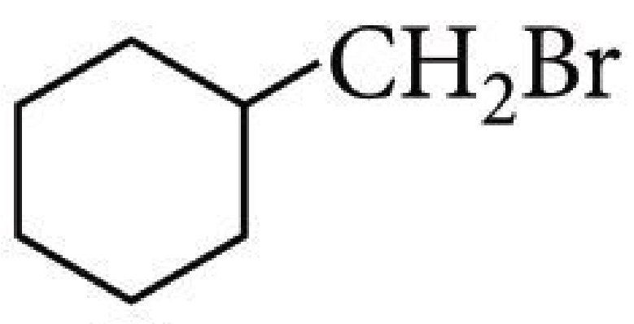
17. What is the order of dehydrohalogenation of the following compounds in presence of strong base?



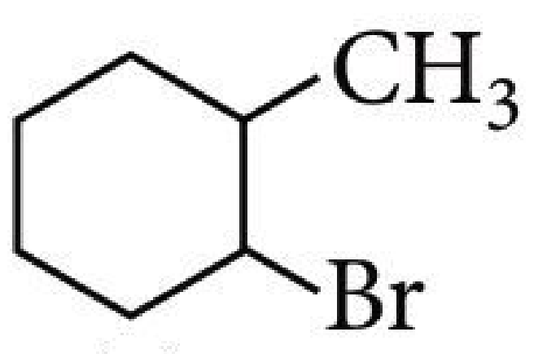
(1)



(2)



(3)

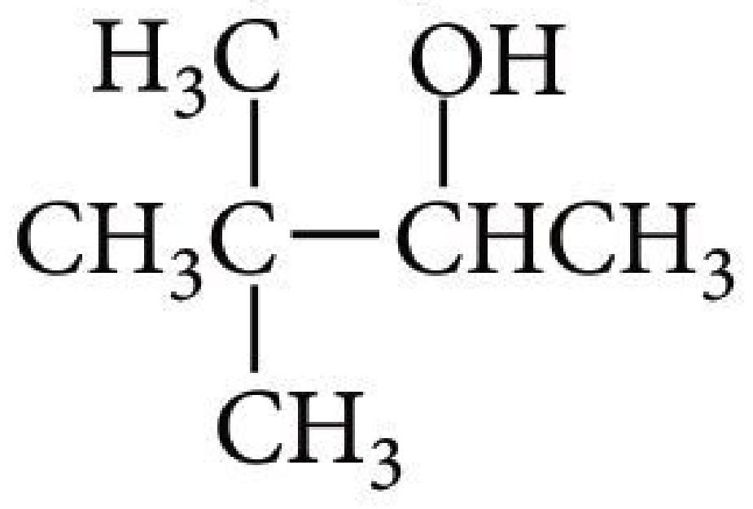


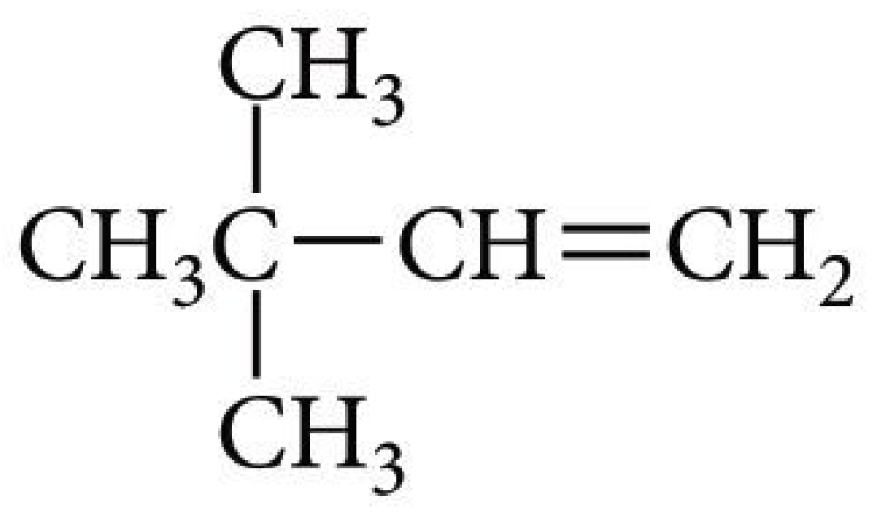
(4)

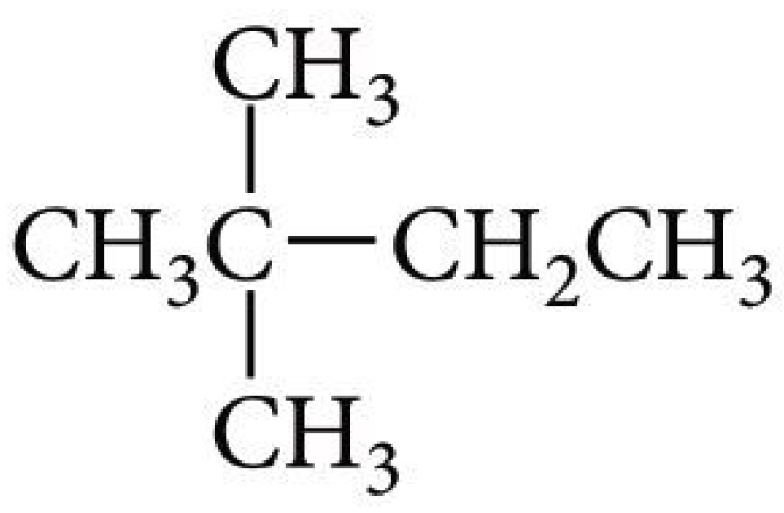
(a) 1 > 2 > 3 > 4 (b) 2 > 4 > 3 > 1

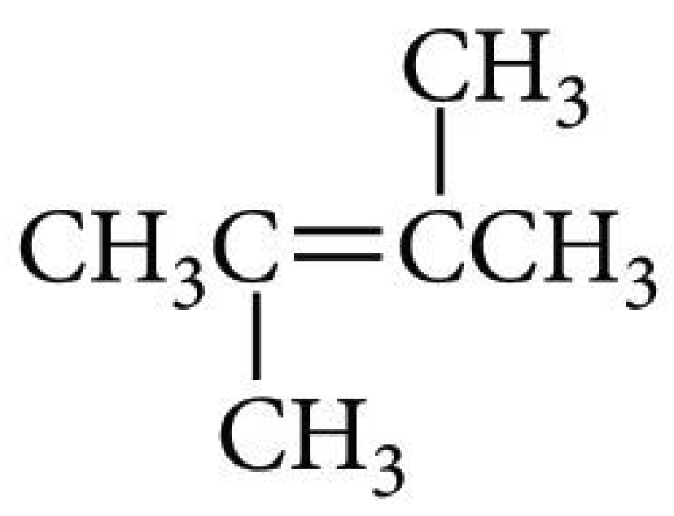
(c) 4 > 2 > 1 > 3 (d) 1 > 2 > 4 > 3

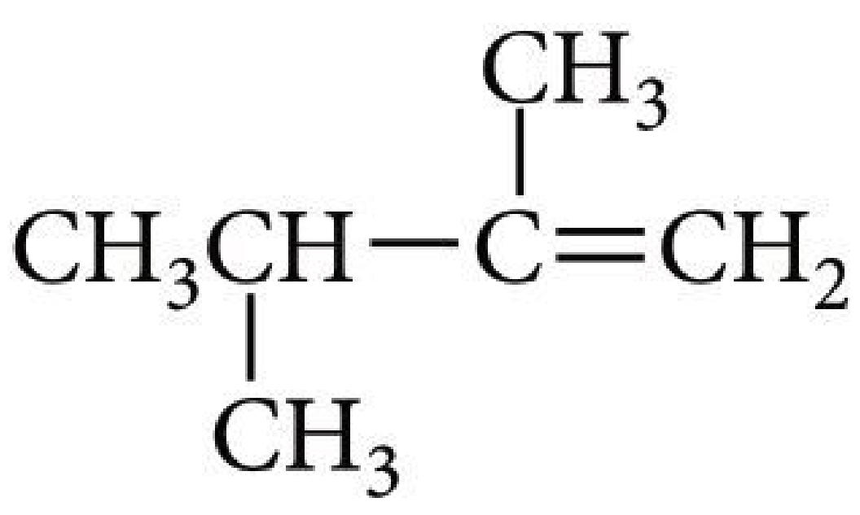
18. Select the major product of the dehydration of the alcohol


$CH_3\overset{H_3C}{\underset{CH_3}{C}}-\overset{OH}{C}HCH_3$

(a)

$CH_3\overset{CH_3}{\underset{CH_3}{C}}-CH{=}CH_2$

(b)

$CH_3\overset{CH_3}{\underset{CH_3}{C}}-CH_2CH_3$

(c)

$CH_3\underset{CH_3}{C}{=}\overset{CH_3}{C}CH_3$

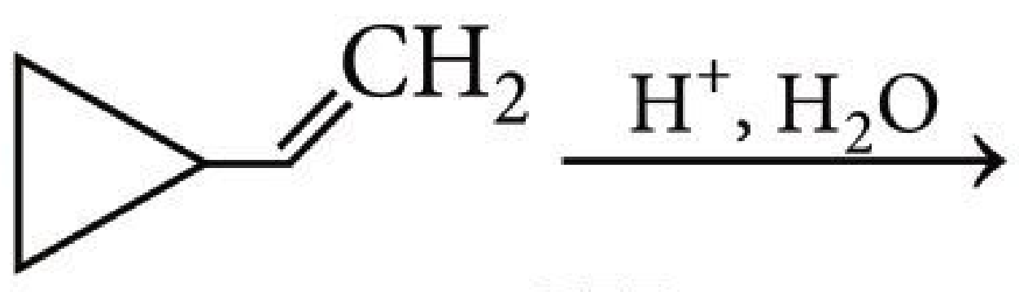
(d)

$CH_3\underset{CH_3}{C}H-\overset{CH_3}{C}{=}CH_2$

19. A water sample has ppm level concentration of following anions, $F^- = 10$; $SO_4^{2-} = 100$; $NO_3^- = 50$. The anion/anions that make/makes the water sample unsuitable for drinking is/are

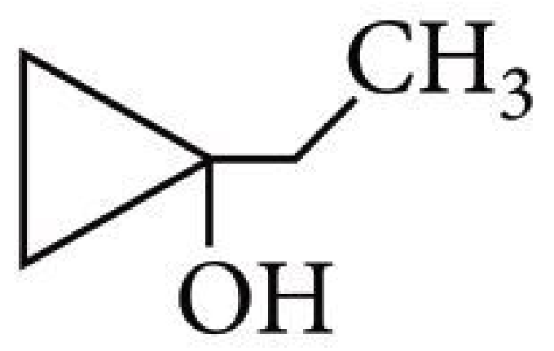
(a) only F^- (b) only SO_4^{2-}

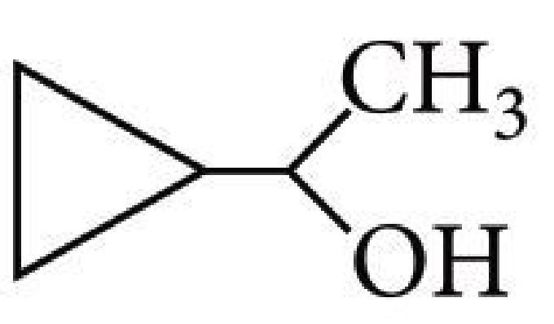
(c) only NO_3^- (d) both SO_4^{2-} and NO_3^-

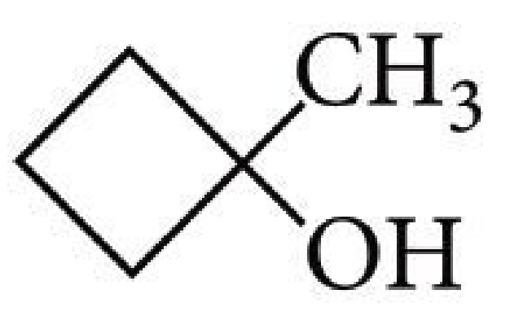
More than One Option Correct Type

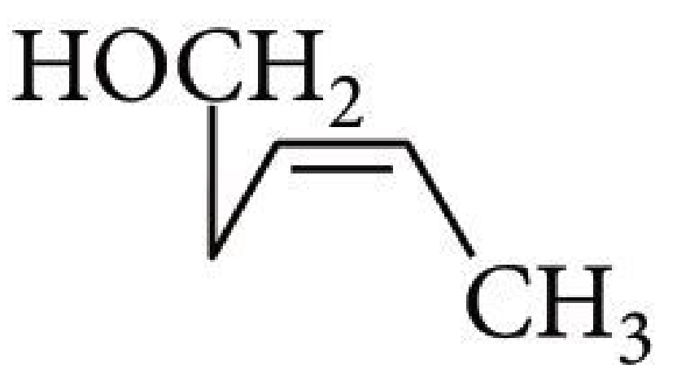
20.


Product. Product(s) is/are

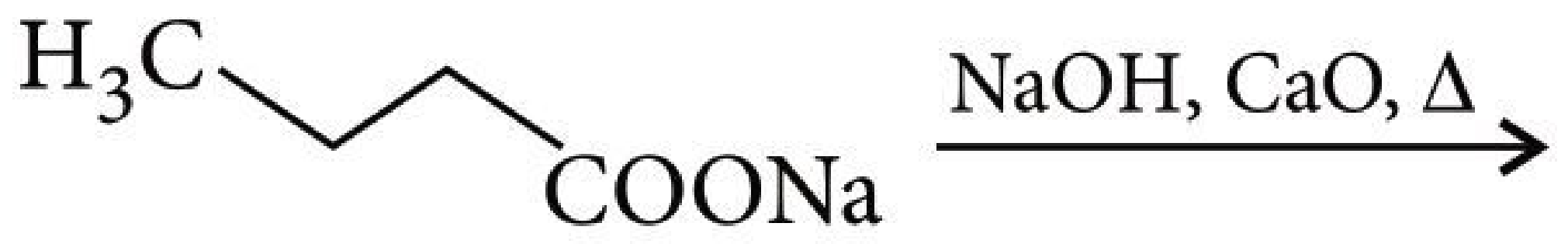
(a)


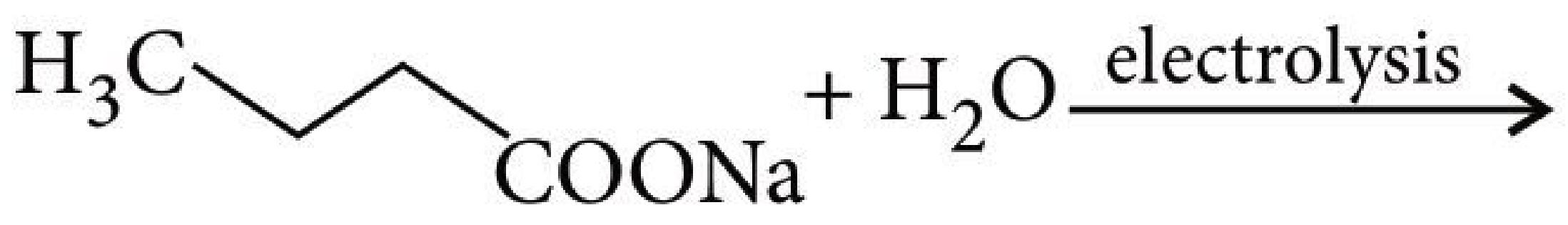
(b)


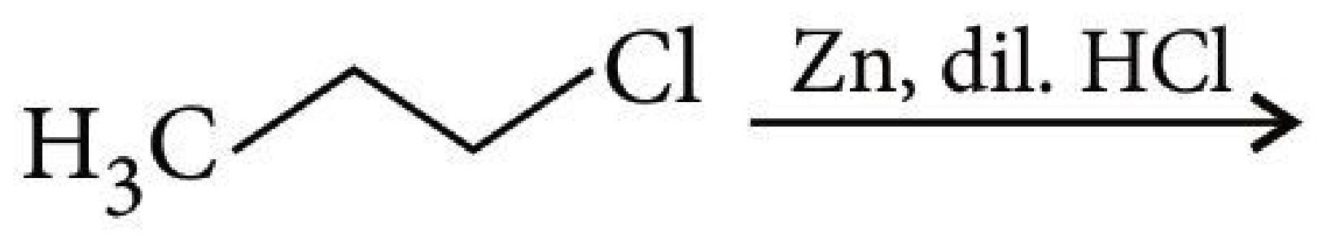
(c)


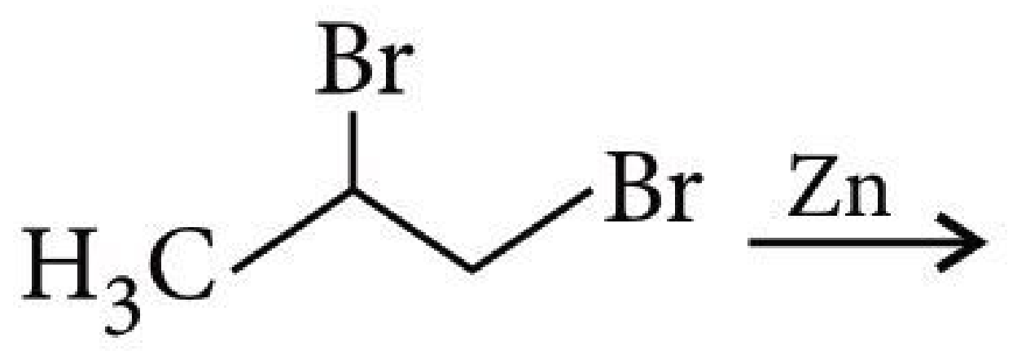
(d)


21. Which of the following reactions produce(s) propane as a major product?

(a) 

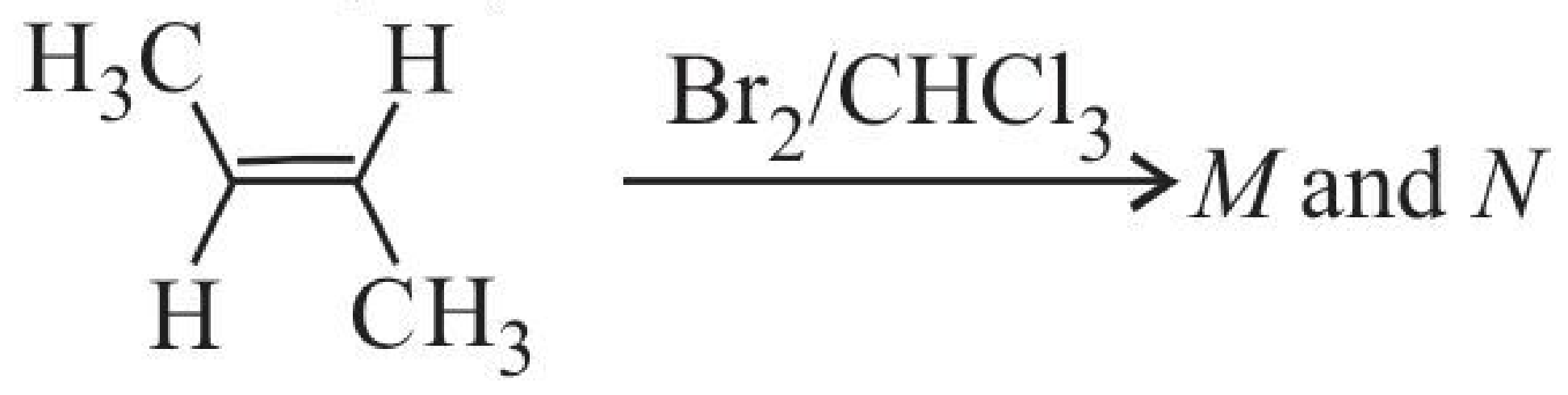
(b) 

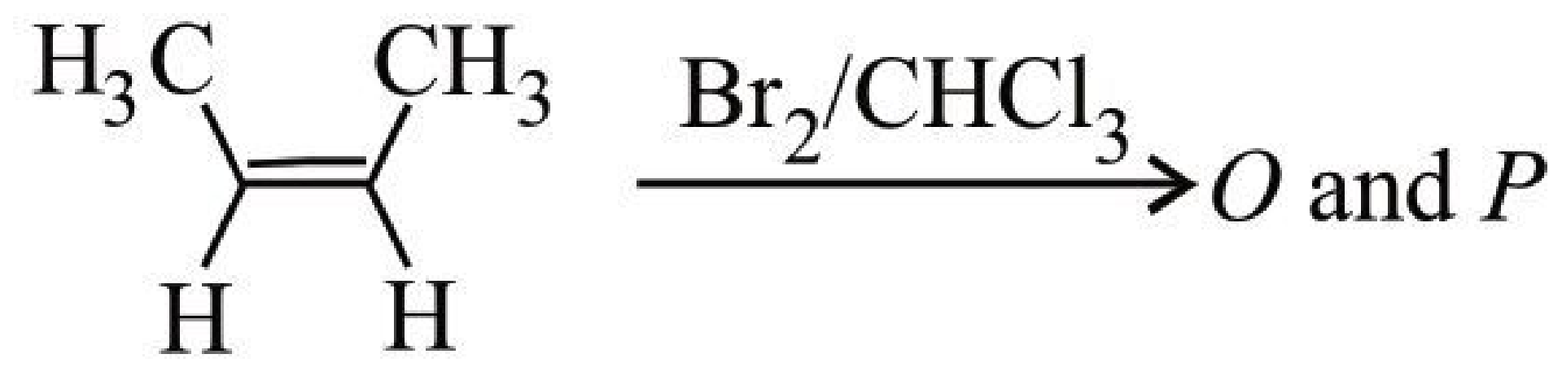
(c) 

(d) 

22. Generally, which of the following is not a sink for CO?
(a) Microorganisms present in the soil
(b) Oceans (c) Plants
(d) Haemoglobin

23. The correct statement(s) for the following addition reactions is(are)

(i) 

(ii) 

(a) *O* and *P* are identical molecules
(b) bromination proceeds through *trans*-addition in both the reactions
(c) (*M* and *O*) and (*N* and *P*) are two pairs of enantiomers
(d) (*M* and *O*) and (*N* and *P*) are two pairs of diastereomers.

Integer / Numerical Value Type

24. What is the oxidation state of chromium in chromium compound which is used as an oxidant in chemical oxygen demand (COD)?

25. Compound (*A*) with molecular weight 108 contained 88.89% C and 11.11% H. It gave a white precipitate with ammoniacal silver nitrate. Complete hydrogenation of (*A*) gave another compound (*B*) with molecular weight 112. Oxidation of (*B*) gave an acid with equivalent weight 128. Decarboxylation of this acid gave cyclohexane. The number of *sp* hybridised carbon atoms in (*A*) are _________ .

26. 11.14 g of 1,1,2,2-tetrachloropropane was heated with zinc dust and the product was bubbled through ammoniacal $AgNO_3$. The mass of precipitate obtained is _________ .

PUBLIC NOTICE

JEE MAIN 2023

The Department of Higher Education, Ministry of Education, Government of India has entrusted the responsibility of conducting the Joint Entrance Examination (JEE Main) to the NTA from 2019 onwards.

The Joint Entrance Examination (JEE (Main) comprises two papers. **Paper 1 (B.E./B.Tech.)** is conducted for admission to Undergraduate Engineering Programs (B.E/B. Tech) at NITs, IIITs, other Centrally Funded Technical Institutions (CFTIs), Institutions/Universities funded/recognized by participating State Governments. It is also an eligibility test for JEE (Advanced), which is conducted for admission to IITs. **Paper 2** is conducted for admission to **B. Arch and B. Planning** courses in the Country.

For Academic Session 2023-24, it has been decided that the **JEE (Main) – 2023 will be conducted in two Sessions i.e. Session 1 (January 2023) and Session 2 (April 2023)**. The details for the **Session 1 (January 2023)** are given below :

Online Submission of Application Form	**15 December 2022 to 12 January 2023 (up to 09:00 P.M.)**
Last date of successful transaction of fee through Credit/Debit Card/ Net-Banking/UPI	**12 January 2023 (up to 11:50 P.M.)**
Announcement of the City of Examination	**Second week of the January 2023**
Downloading of Admit Cards from the NTA website	**Third week of the January 2023**
Date of Examination	**24, 25, 27, 28, 29, 30 and 31 January 2023**
Centre, Date, and Shift	As indicated on Admit Card
Display of Recorded Responses and Answer Keys	To be announced later on the website
Website(s)	www.nta.ac.in, https://jeemain.nta.nic.in/
Declaration of Result on the NTA website	*To be announced later on the website*

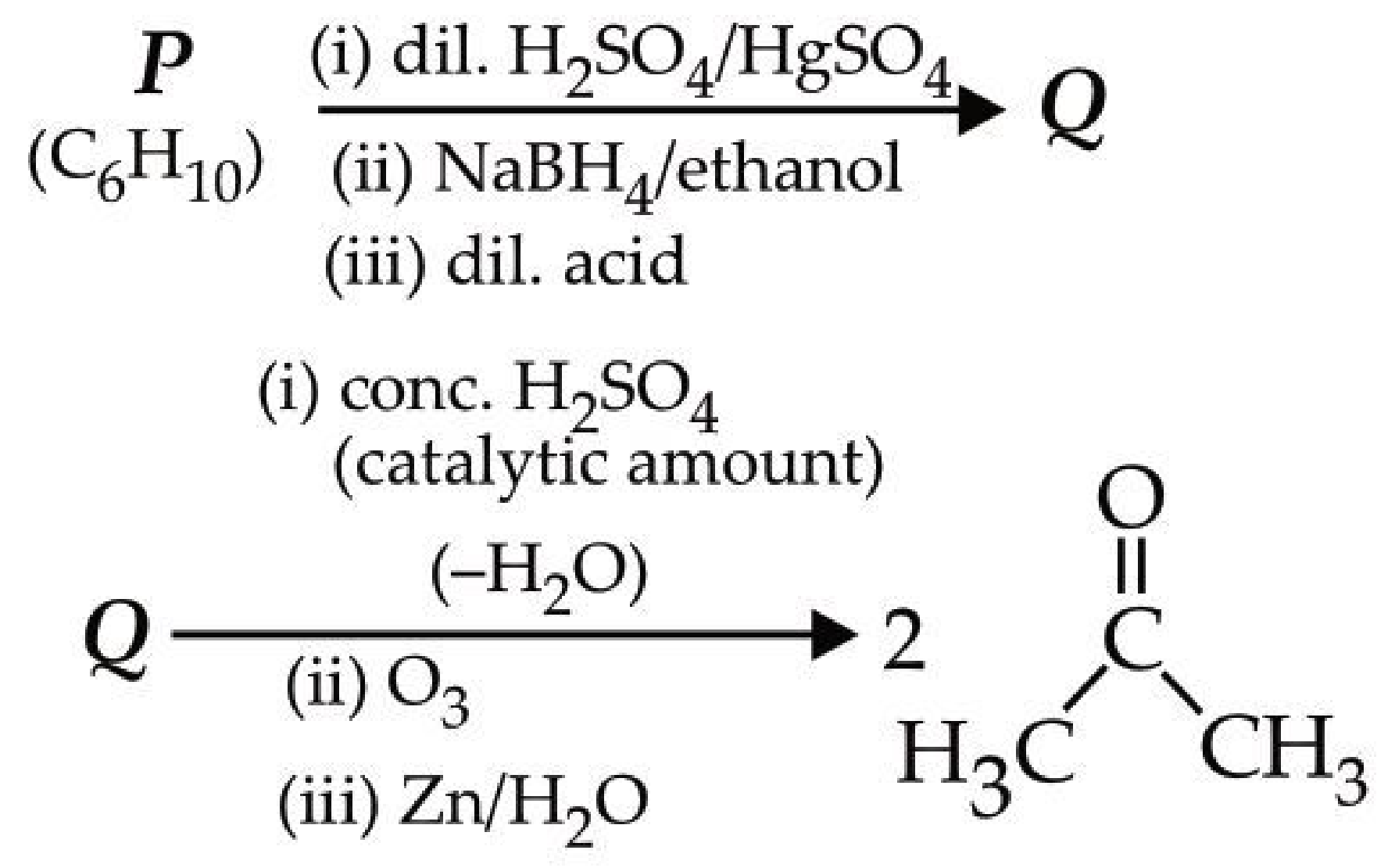
JEE (Main) - 2023 will be conducted in **13 languages** i.e. **English, Hindi, Assamese, Bengali, Gujarati, Kannada, Malayalam, Marathi, Odia, Punjabi, Tamil, Telugu, and Urdu.**

In the first session of JEE (Main) - 2023, only Session 1 will be visible and candidates can opt for that. In the next session, Session 2 will be visible, and the candidates can opt for that Session. The application window for Session 2 will be re-opened as per the details available in the Information Bulletin and will also be notified separately through a Public Notice.

For Papers, Scheme, Timing, eligibility and other information, candidates are requested to please check the Information Bulletin of JEE (Main) – 2023 available on the website: https://jeemain.nta.nic.in/

Comprehension Type

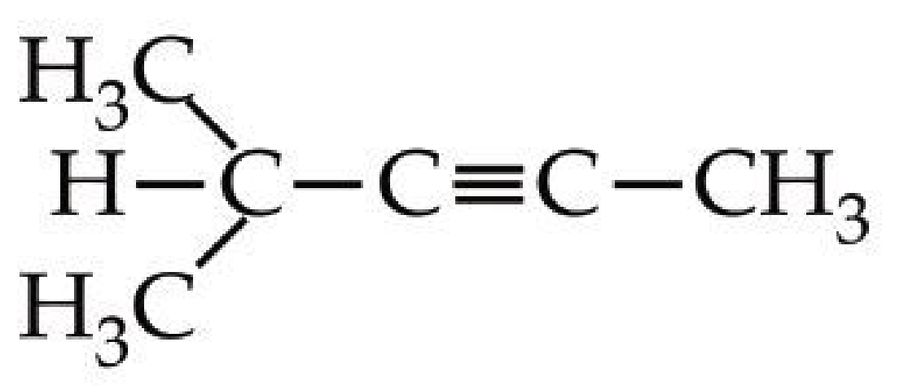
An acyclic hydrocarbon *P*, having molecular formula C_6H_{10}, gave acetone as the only organic product through the following sequence of reactions, in which *Q* is an intermediate organic compound.

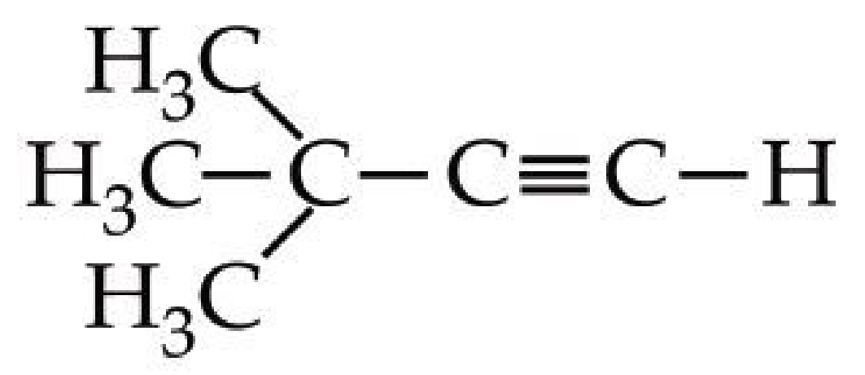


27. The structure of compound *P* is

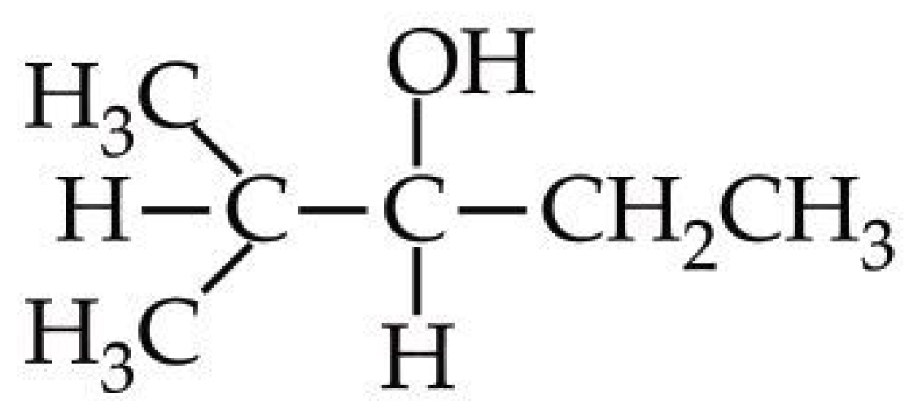
(a) $CH_3CH_2CH_2CH_2-C\equiv C-H$

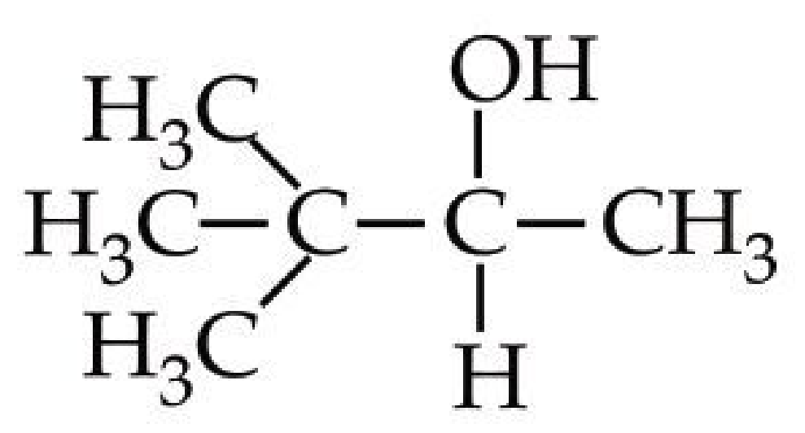
(b) $H_3CCH_2-C\equiv C-CH_2CH_3$

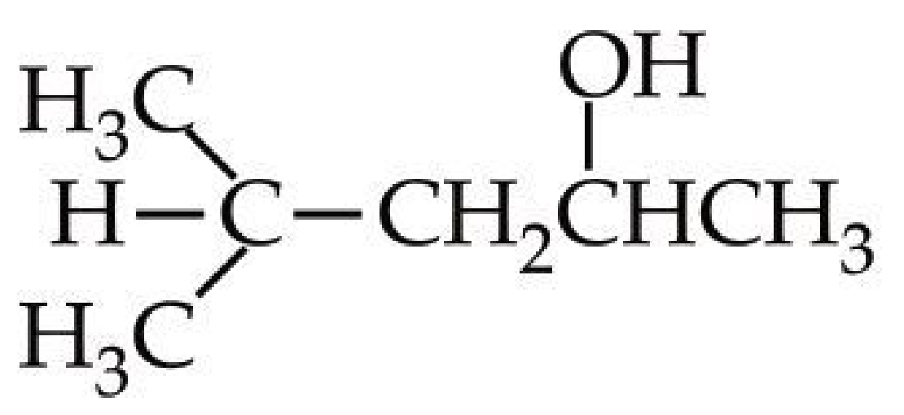
(c) 
$(H_3C)_2CH-C\equiv C-CH_3$

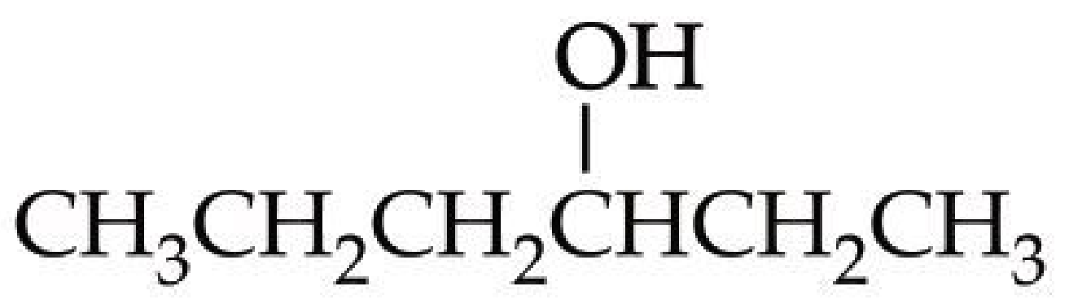
(d) 
$(H_3C)_3C-C\equiv C-H$

28. The structure of the compound *Q* is

(a) 
$(H_3C)_2CH-CH(OH)-CH_2CH_3$

(b) 
$(H_3C)_3C-CH(OH)-CH_3$

(c) 
$(H_3C)_2CH-CH_2CH(OH)CH_3$

(d) 
$CH_3CH_2CH_2CH(OH)CH_2CH_3$

Matching Type

29. Match the pollutants in column-I with the effect(s) in column-II.

	Column-I		Column-II
(A)	Oxides of sulphur	(i)	Global warming
(B)	Nitrogen dioxide	(ii)	Damage to kidney
(C)	Carbon dioxide	(iii)	'Blue baby' syndrome
(D)	Nitrate in drinking water	(iv)	Respiratory disease
(E)	Lead	(v)	Red haze in traffic and congested areas

The correct option is

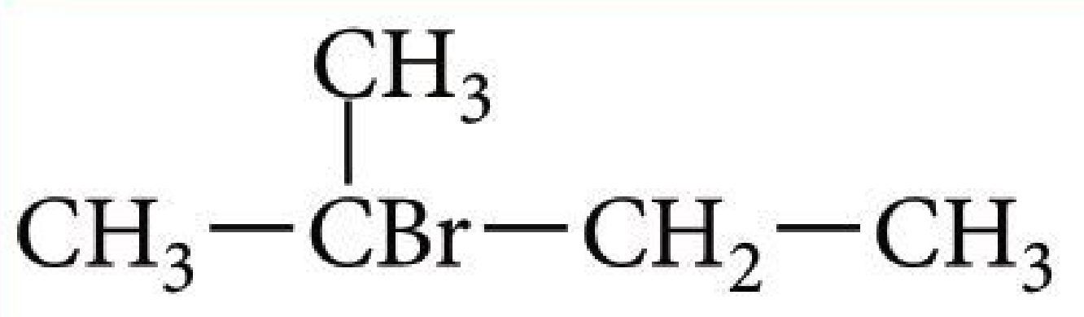
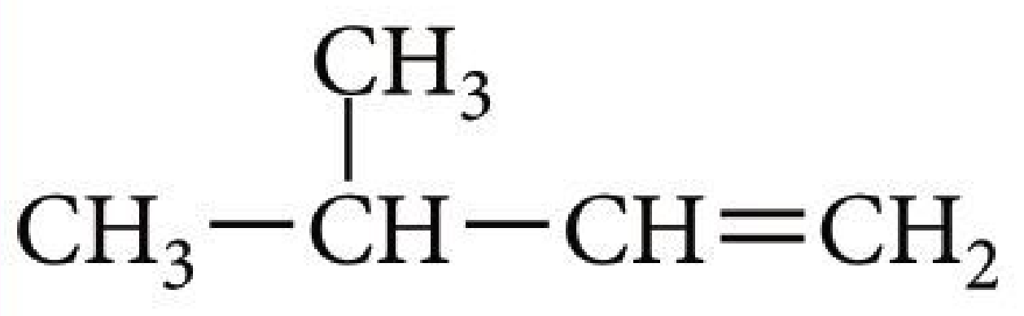
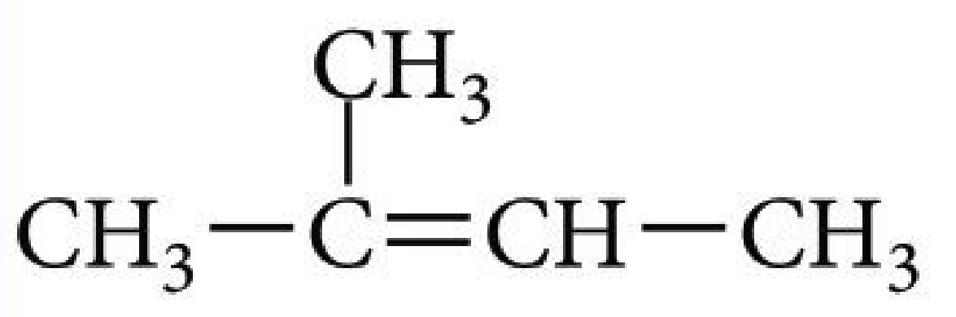
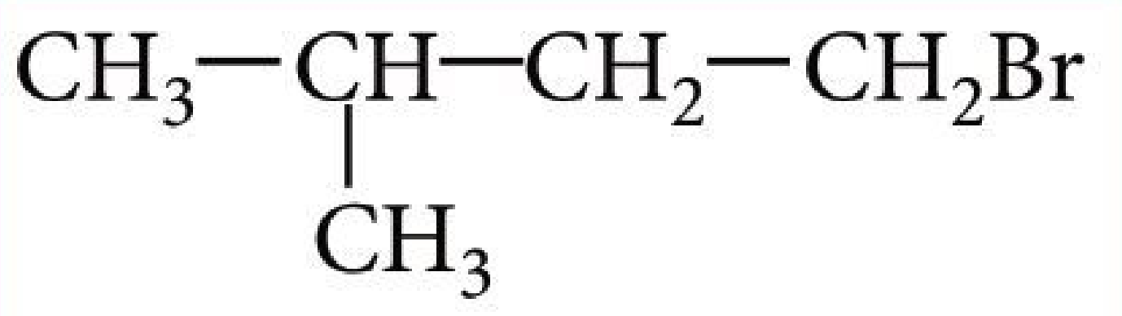
(a) (A) → (i), (B) → (v), (C) → (iii), (D) → (ii), (E) → (iv)

(b) (A) → (iv), (B) → (v), (C) → (i), (D) → (iii), (E) → (ii)

(c) (A) → (ii), (B) → (iv), (C) → (i), (D) → (ii), (E) → (iii)

(d) (A) → (i), (B) → (iii), (C) → (iv), (D) → (ii), (E) → (v)

30. Match the column-I with column-II and select the correct option.

	Column-I		Column-II
(A)	 $CH_3-CBr(CH_3)-CH_2-CH_3$	(i)	Markovnikov's product
(B)	 $CH_3-CH(CH_3)-CH=CH_2$	(ii)	Peroxide effect
(C)	 $CH_3-C(CH_3)=CH-CH_3$	(iii)	Saytzeff's product
(D)	 $CH_3-CH(CH_3)-CH_2-CH_2Br$	(iv)	Hoffmann's product

(a) (A) → (ii), (B) → (i), (C) → (iii), (D) → (iv)

(b) (A) → (iv), (B) → (ii), (C) → (i), (D) → (iii)

(c) (A) → (i), (B) → (iii), (C) → (ii), (D) → (iv)

(d) (A) → (i), (B) → (iv), (C) → (iii), (D) → (ii)

◆◆

Keys are published in this issue. Search now! ☺

SELF CHECK

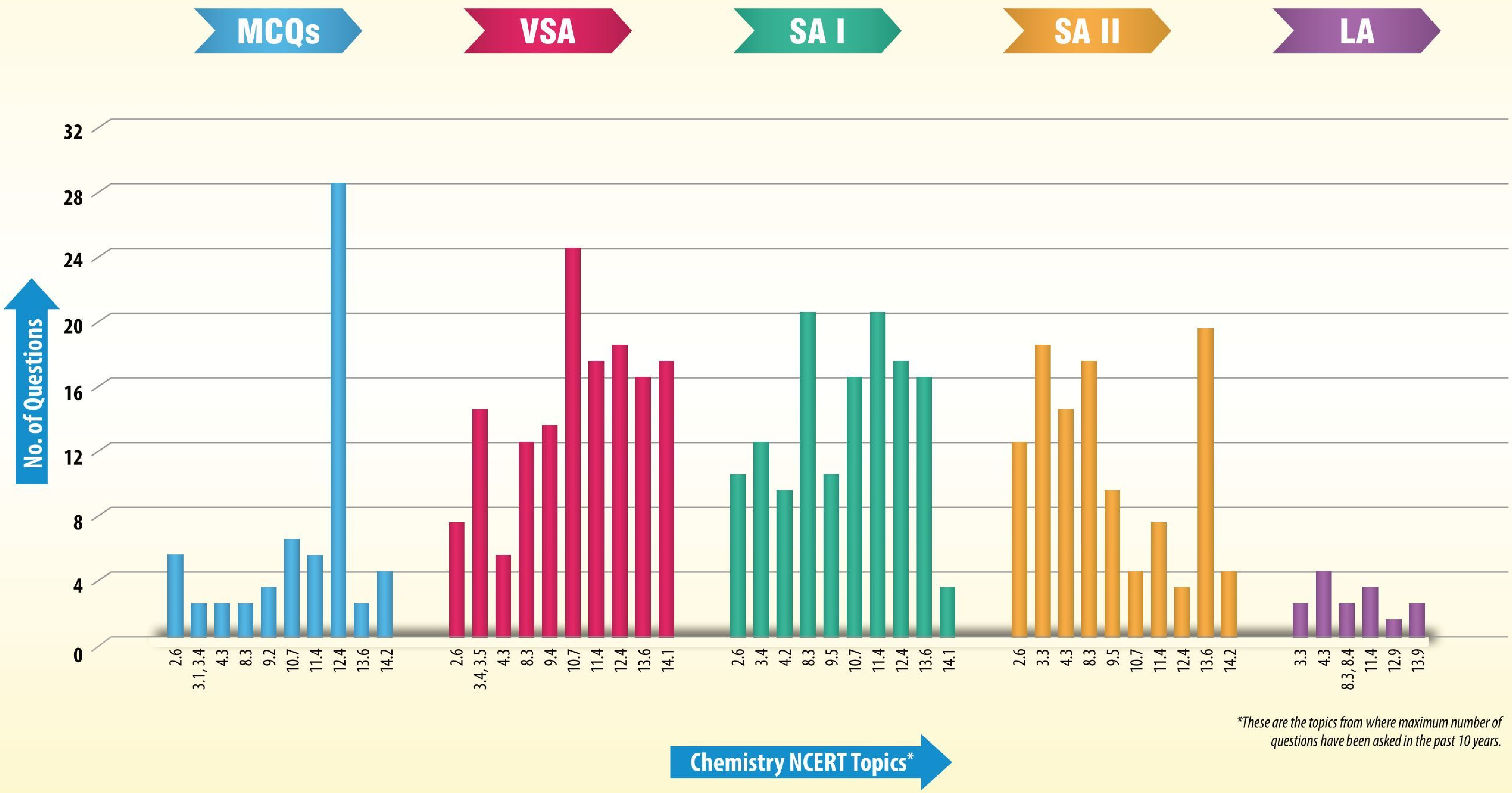
No. of questions attempted ……
No. of questions correct ……
Marks scored in percentage ……

Check your score! If your score is

> 90%	**EXCELLENT WORK !**	You are well prepared to take the challenge of final exam.
90-75%	**GOOD WORK !**	You can score good in the final exam.
74-60%	**SATISFACTORY !**	You need to score more next time.
< 60%	**NOT SATISFACTORY!**	Revise thoroughly and strengthen your concepts.

Are You Ready for CBSE Board Exams?

Past 10 Years (2013-2022) Chapterwise and Topicwise Trend Analysis of CBSE Board Questions



*These are the topics from where maximum number of questions have been asked in the past 10 years.

Some of the important topics extracted from graphical analysis are explained here.

Chapter 2 : Solutions

Solution is a homogeneous mixture of solvent and solute.

Methods of expressing concentration of a solution :

- **Molarity** $= \dfrac{w_{\text{solute}} \times 1000}{M_{\text{solute}} \times V_{\text{soln}}(\text{in mL})}$
- **Molality** $= \dfrac{w_{\text{solute}} \times 1000}{M_{\text{solute}} \times w_{\text{solvent}}(\text{in g})}$
- **Mass percentage** $= \dfrac{\text{Weight of solute}}{\text{Weight of solution}} \times 100$
- **Volume percentage** $= \dfrac{\text{Volume of solute}}{\text{Volume of solution}} \times 100$
- **Parts per million** $= \dfrac{\text{Mass of component}}{\text{Total mass of solution}} \times 10^6$
- **Mole fraction**

$$x_{\text{solute}} = \frac{n}{n+N};\ x_{\text{solvent}} = \frac{N}{n+N};\quad x_{\text{solute}} + x_{\text{solvent}} = 1$$

TYPES OF SOLUTIONS

Solution of Gas in Liquid

Henry's law :

Mole fraction (x) ∝ Partial pressure of gas (p)

$x = K_H p$ (K_H - Henry's constant)

Applications :

(i) Addition of CO_2 in soft drinks and soda water.

(ii) Scuba divers use air diluted with helium (11.7%) for breathing to avoid bends.

Solution of a Liquid in a Liquid

Raoult's law : For a solution of volatile liquids, the partial vapour pressure of each component of the solution is directly proportional to its mole fraction present in solution, *i.e.*, $p_1 = p_1^\circ x_1$ and $p_2 = p_2^\circ x_2$.

Dalton's law of partial pressures :

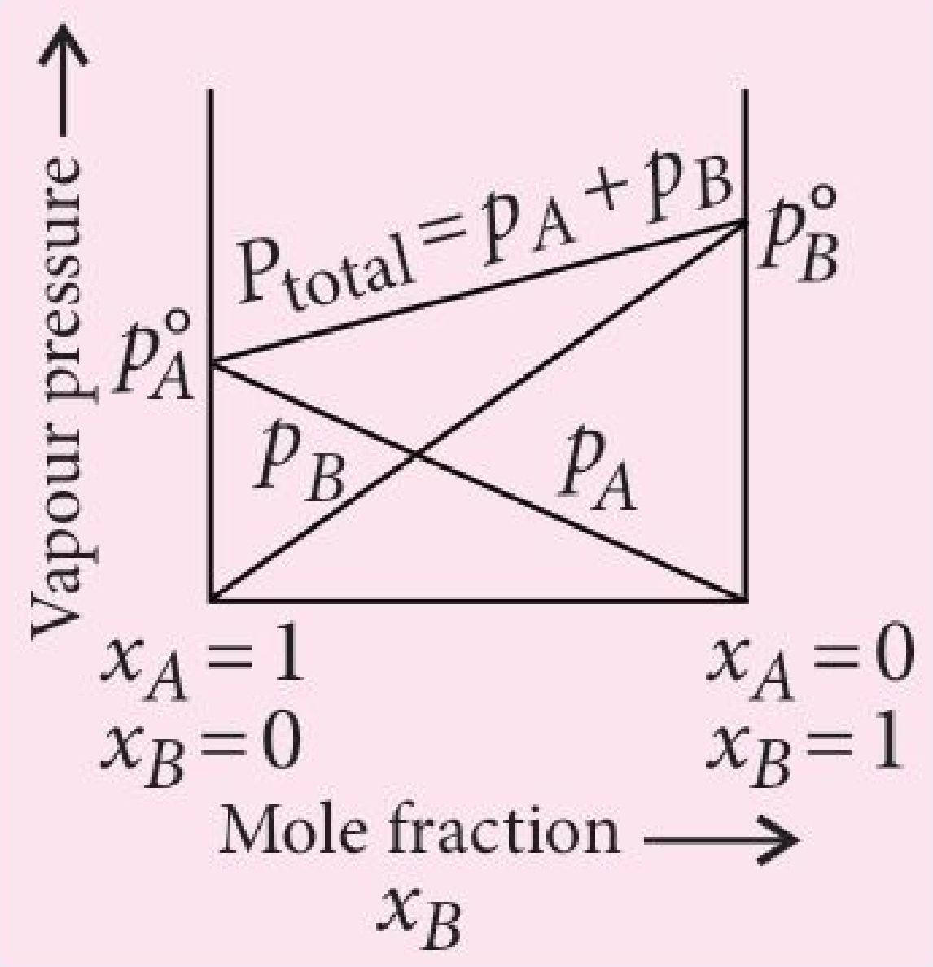
$$P_{\text{total}} = p_1 + p_2 = x_1 p_1^\circ + x_2 p_2^\circ$$
$$= (1 - x_2)p_1^\circ + x_2 p_2^\circ = p_1^\circ + (p_2^\circ - p_1^\circ)x_2$$

In the vapour phase, $p_1 = y_1 P_{\text{total}}$ and $p_2 = y_2 P_{\text{total}}$.

Liquid - liquid solutions are classified as ideal and non-ideal solutions as discussed below:

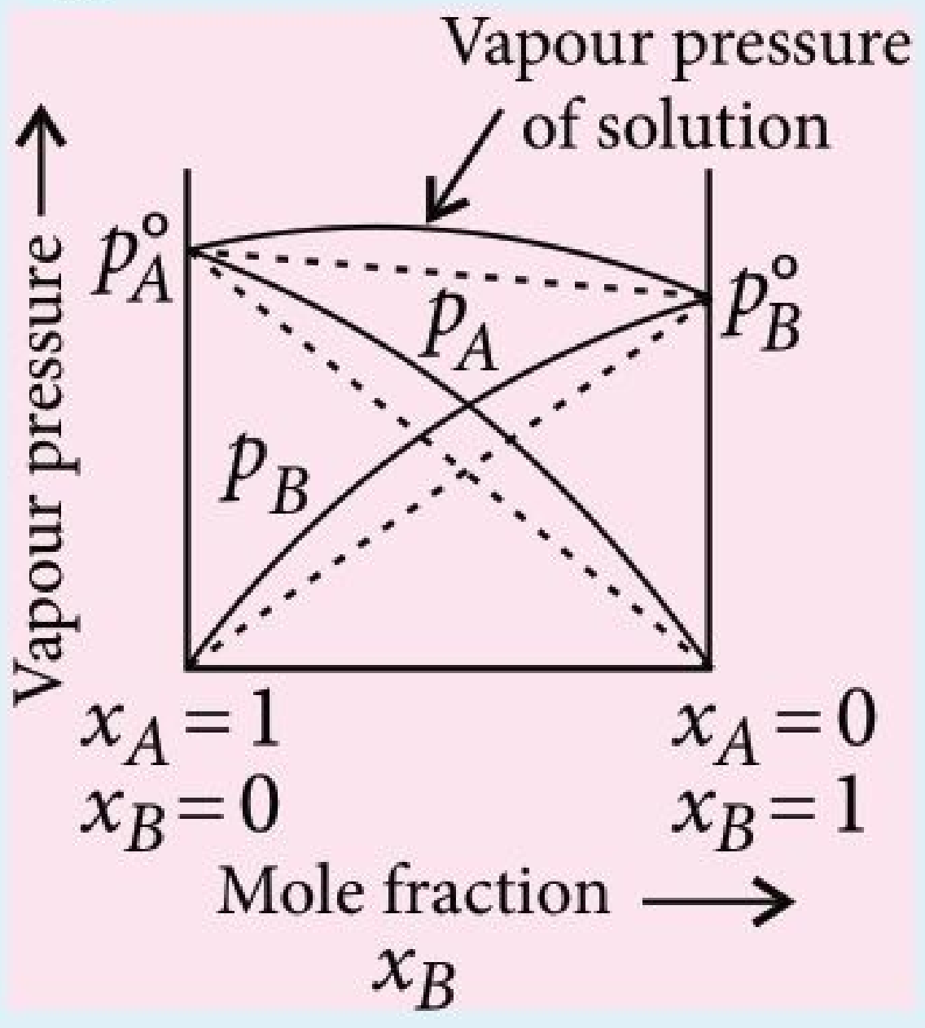
Ideal solution :

$A - B$ interaction ≈ $A - A$ ≈ $B - B$ interaction, $\Delta H_{\text{mix}} = 0$, $\Delta V_{\text{mix}} = 0$ *e.g* : benzene + toluene, *n*-hexane + *n*-heptane

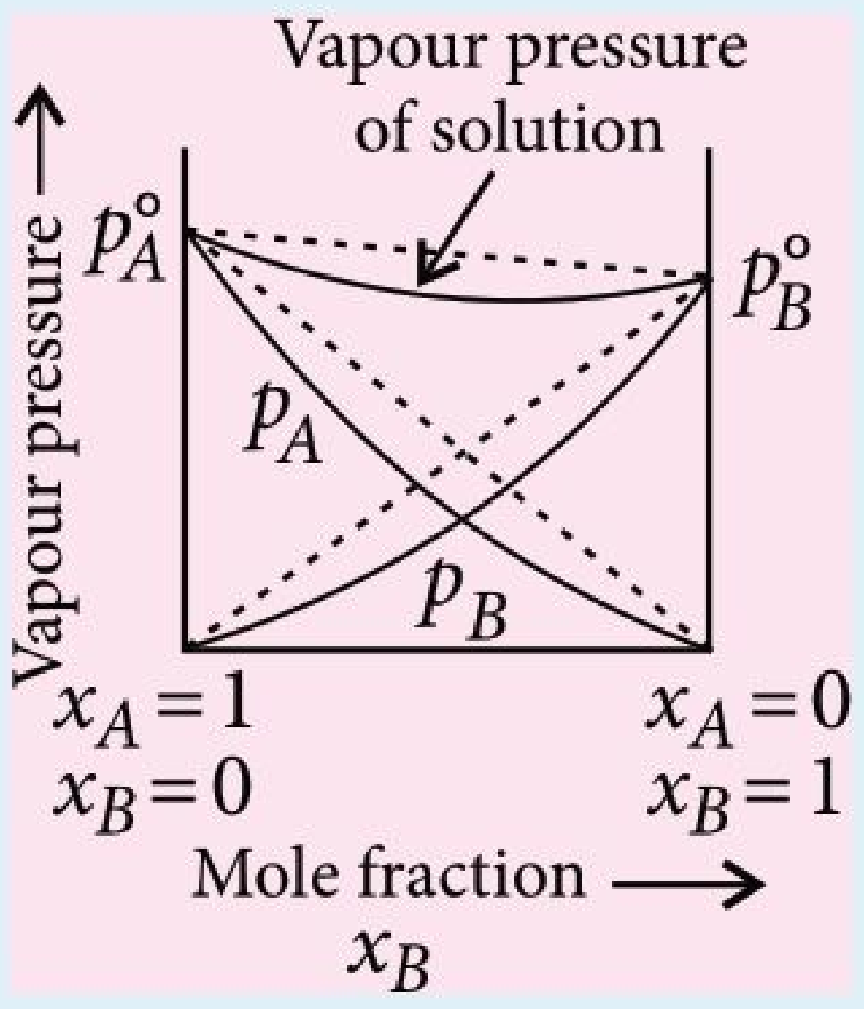


Non-ideal solution :

- Solution showing negative deviation from Raoult's law : $A - B$ interaction >>> $A - A$ or $B - B$ interactions $\Delta H_{\text{mix}} < 0$, $\Delta V_{\text{mix}} < 0$, *e.g.*, acetone and chloroform.
- Solution showing positive deviation from Raoult's law: $\Delta H_{\text{mix}} > 0, \Delta V_{\text{mix}} > 0, A - B$ interaction <<< $A - A$ or $B - B$ interactions.
  e.g : acetone + ethanol, water + methanol



Positive deviation



Negative deviation

Azeotropes : Mixture of liquids that boil at constant temperature and have same composition in liquid and vapour phase.

- **Minimum boiling azeotropes :** These are formed by those liquid pairs which show positive deviation from Raoult's law, *e.g.*, ethanol-water mixture.
- **Maximum boiling azeotropes :** These are formed by those liquid pairs which show negative deviation from Raoult's law, *e.g.*, nitric acid-water mixture.

Solution of a Solid in a Liquid

Raoult's law for solid-liquid solutions : It states that relative lowering in vapour pressure of a solution containing a non-volatile solute is equal to the mole fraction of the solute, *i.e.*, $\dfrac{p^\circ - p_s}{p^\circ} = x_2$.

Colligative Properties : Properties which depend on number of solute particles in solution.

- Relative lowering of vapour pressure

$$\frac{p_1^\circ - p_1}{p_1^\circ} = x_2 = \frac{n_2}{n_1+n_2} = \frac{n_2}{n_1} = \frac{w_2\times M_1}{M_2\times w_1}$$

(∵ for dilute solutions, $n_2 << n_1$)

- Elevation in boiling point

$\Delta T_b = T_b - T_b^\circ$; $\Delta T_b \propto m$ or $\Delta T_b = K_b m$

$$= K_b\left(\frac{w_2\times 1000}{M_2\times w_1(\text{in g})}\right) \text{ or } M_2 = \frac{K_b\times w_2\times 1000}{\Delta T_b\times w_1(\text{in g})}$$

- Depression in freezing point

$\Delta T_f = T_f^\circ - T_f$; $\Delta T_f \propto m$ or $\Delta T_f = K_f m$

$$= K_f\left(\frac{w_2\times 1000}{M_2\times w_1(\text{in g})}\right) \text{ or } M_2 = \frac{K_f\times w_2\times 1000}{\Delta T_f\times w_1(\text{in g})}$$

- Osmotic pressure

$$\pi = CRT = \left(\frac{n_2}{V}\right)RT\ ,\ \pi V = \frac{w_2RT}{M_2} \text{ or } M_2 = \frac{w_2RT}{\pi V}$$

- Two solutions having same osmotic pressure at a given temperature are called *isotonic solutions*.
- If one solution is of lower osmotic pressure, it is called *hypotonic* with respect to the more concentrated solution. The more concentrated solution is said to be *hypertonic* with respect to the dilute solution.
- If a pressure higher than the osmotic pressure is applied on the solution, the solvent will flow from the solution into the pure solvent through the semipermeable membrane and the process is called *reverse osmosis*. It is used in *desalination of sea water*.

Abnormal Molecular Weight and van't Hoff Factor

$$i = \frac{\text{Observed colligative property}}{\text{Calculated colligative property}} = \frac{\text{Calculated Mol. mass}}{\text{Observed Mol. mass}}$$

$$i = \frac{\text{no. of moles after association/dissociation}}{\text{no. of moles before association/dissociation}}$$

- If $i > 1$, solute undergoes dissociation and if $i < 1$, solute undergoes association.

$$\alpha_{\text{dissociation}} = \frac{i-1}{n-1};\ \alpha_{\text{association}} = \frac{1-i}{1-\frac{1}{n}}$$

- For substances undergoing association or dissociation in the solution, colligative properties are given as,

$$\frac{p_1^\circ - p_1}{p_1^\circ} = ix_2;\ \Delta T_b = iK_bm;\ \Delta T_f = iK_fm; \pi = iCRT$$

Chapter 3 : Electrochemistry

Electrochemistry : The study of production of electricity from energy released during spontaneous chemical reactions. There are mainly two types of cells:

Electrochemical cell (Galvanic or Voltaic cell)	Electrolytic cell
Device which converts chemical energy into electrical energy.	Device which converts electrical energy into chemical energy.
$\Delta G = -\text{ve}$	$\Delta G = +\text{ve}$

NERNST EQUATION

For a reduction reaction, $M^{n+}_{(aq)} + ne^- \longrightarrow M_{(s)}$;

$$E_{\text{cell}} = E^\circ_{\text{cell}} - \frac{0.0591}{n}\log\frac{1}{[M^{n+}_{(aq)}]}$$

Applications of Nernst equation :

- **To calculate electrode potential of a cell :**

$$aA + bB \xrightarrow{ne^-} xX + yY$$

$$E_{\text{cell}} = E^\circ_{\text{cell}} - \frac{0.0591}{n}\log\frac{[X]^x[Y]^y}{[A]^a[B]^b}$$

- **To calculate equilibrium constant :**

At equilibrium, $E_{\text{cell}} = 0$; $E^\circ_{\text{cell}} = \frac{0.0591}{n}\log K_c$ at 298 K

Relation between standard cell potential and standard Gibbs free energy change : $\Delta G^\circ = -nFE^\circ_{\text{cell}}$; $\Delta G^\circ = -2.303\, RT\log K_c$

CONDUCTANCE IN ELECTROLYTIC SOLUTIONS

Property	Formula	Effect of dilution
Conductance (G) **Units :** Ohm^{-1} (Ω^{-1}) or Siemens (S)	$\frac{1}{R} = \frac{A}{\rho l} = \frac{\kappa A}{l}$	Increases as larger number of ions are produced.

Specific conductance (κ) **Units :** Ohm^{-1} cm^{-1} or $S\ m^{-1}$	$\frac{1}{\rho}$ or $G\frac{l}{A}$	Decreases as number of ions per cm^3 decreases.
Molar conductivity (Λ_m) **Units :** $\Omega^{-1}\ cm^2\ mol^{-1}$ or $S\ m^2\ mol^{-1}$	$\kappa \times V$ or $\kappa \times \frac{1000}{M}$	Increases with dilution due to large increase in V.

Limiting molar conductivity : When concentration approaches zero *i.e.* ; at infinite dilution, the molar conductivity is known as *limiting molar conductivity* (Λ°_m).

Kohlrausch's law of independent migration of ions: $\Lambda^\circ_m = \upsilon_+\lambda^\circ_+ + \upsilon_-\lambda^\circ_-$; where λ°_+ and λ°_- are the limiting molar conductivities of the cation and anion respectively and υ_+ and υ_- are stoichiometric number of cations and anions respectively in one formula unit of the electrolyte.

Applications of Kohlrausch's law :

- **Calculation of molar conductivity of weak electrolytes:** Degree of dissociation (α) = $\frac{\Lambda^c_m}{\Lambda^\circ_m}$
- **Calculation of dissociation constant (K_c) of weak electrolyte :** $K_c = \frac{c\alpha \times c\alpha}{(c - c\alpha)} = \frac{c\alpha^2}{(1-\alpha)}$

Faraday's first law of electrolysis :

$w \propto Q$ or $w = ZQ = Z \times I \times t$

Faraday's second law of electrolysis :

$\frac{w_1}{w_2} = \frac{E_1}{E_2}$; where, E is the equivalent weight.

Products of Electrolysis :

Electrolyte	Products	
	At cathode	**At anode**
Molten NaCl	Na metal	Cl_2 gas
Aqueous NaCl	H_2 gas	Cl_2 gas
Dil. H_2SO_4	H_2 gas	O_2 gas
Conc. H_2SO_4	H_2 gas	$S_2O_8^{2-}$

BATTERIES

A battery is a combination of cells in series. Two type of batteries are :

Primary : Dry cell ; used in transistor or clocks.

Secondary : Rechargeable cell: lead storage battery ; used in automobiles and inverters.

Chapter 9 : Coordination Compounds

Addition compounds : The compounds formed by combination of two or more simple compounds are called *addition compounds.*

They are of two types :

Double salt : These are the compounds which dissociate completely into its constituent ions.

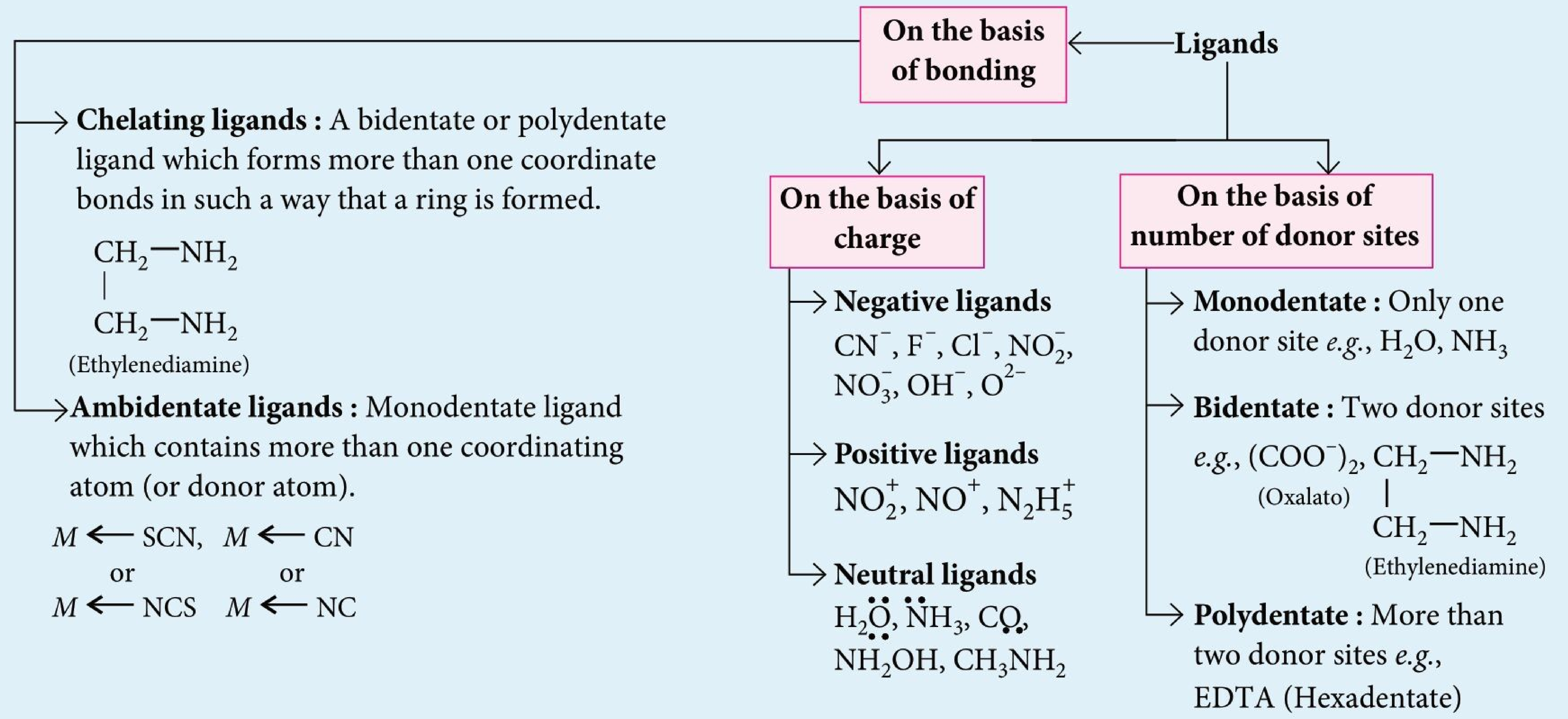
e.g., $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$; Potash alum

Complex compound : A compound formed by combination of two or more simple compounds which retain its identity both in solid and solution states.

WERNER'S COORDINATION THEORY

- It explains the nature of bonding in complexes. According to Alfred Werner, metal shows two different kinds of valencies:
  - **Primary valency :** Non-directional and ionisable. It is equal to the oxidation state of the central metal ion.
  - **Secondary valency :** Directional and non-ionisable. It is equal to the coordination number of the metal. It is commonly satisfied by neutral and negatively charged or some times by positively charged ligands.

Classification of ligands :



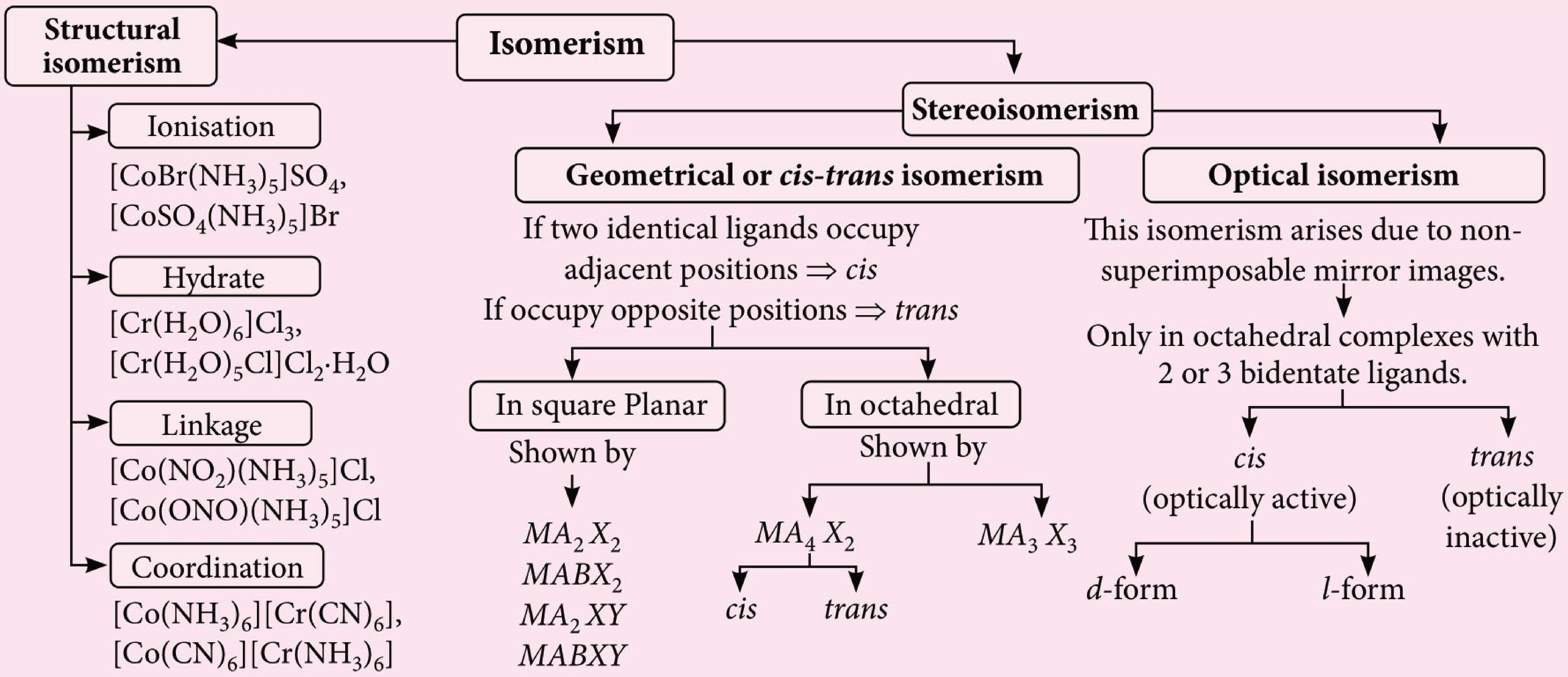
Ligands

- **On the basis of bonding**
  - **Chelating ligands :** A bidentate or polydentate ligand which forms more than one coordinate bonds in such a way that a ring is formed.

    $$\begin{array}{l} CH_2{-}NH_2 \\ | \\ CH_2{-}NH_2 \end{array}$$

    (Ethylenediamine)
  - **Ambidentate ligands :** Monodentate ligand which contains more than one coordinating atom (or donor atom).

    $M \leftarrow SCN$, $M \leftarrow CN$
    or or
    $M \leftarrow NCS$ $M \leftarrow NC$
- **On the basis of charge**
  - **Negative ligands**
    CN^-, F^-, Cl^-, NO_2^-, NO_3^-, OH^-, O^{2-}
  - **Positive ligands**
    NO_2^+, NO^+, $N_2H_5^+$
  - **Neutral ligands**
    $H_2\ddot{O}$, $\ddot{N}H_3$, $C\ddot{O}$, NH_2OH, CH_3NH_2
- **On the basis of number of donor sites**
  - **Monodentate :** Only one donor site *e.g.*, H_2O, NH_3
  - **Bidentate :** Two donor sites
    e.g., $(COO^-)_2$ (Oxalato), $\begin{array}{l} CH_2{-}NH_2 \\ | \\ CH_2{-}NH_2 \end{array}$ (Ethylenediamine)
  - **Polydentate :** More than two donor sites *e.g.*, EDTA (Hexadentate)



Isomerism

- **Structural isomerism**
  - Ionisation
    $[CoBr(NH_3)_5]SO_4$, $[CoSO_4(NH_3)_5]Br$
  - Hydrate
    $[Cr(H_2O)_6]Cl_3$, $[Cr(H_2O)_5Cl]Cl_2{\cdot}H_2O$
  - Linkage
    $[Co(NO_2)(NH_3)_5]Cl$, $[Co(ONO)(NH_3)_5]Cl$
  - Coordination
    $[Co(NH_3)_6][Cr(CN)_6]$, $[Co(CN)_6][Cr(NH_3)_6]$
- **Stereoisomerism**
  - **Geometrical or *cis-trans* isomerism**
    If two identical ligands occupy adjacent positions ⇒ *cis*
    If occupy opposite positions ⇒ *trans*
    - In square Planar
      Shown by
      MA_2X_2
      $MABX_2$
      MA_2XY
      $MABXY$
    - In octahedral
      Shown by
      - MA_4X_2
        - *cis*
        - *trans*
      - MA_3X_3
  - **Optical isomerism**
    This isomerism arises due to non-superimposable mirror images.
    Only in octahedral complexes with 2 or 3 bidentate ligands.
    - *cis* (optically active)
      - *d*-form
      - *l*-form
    - *trans* (optically inactive)

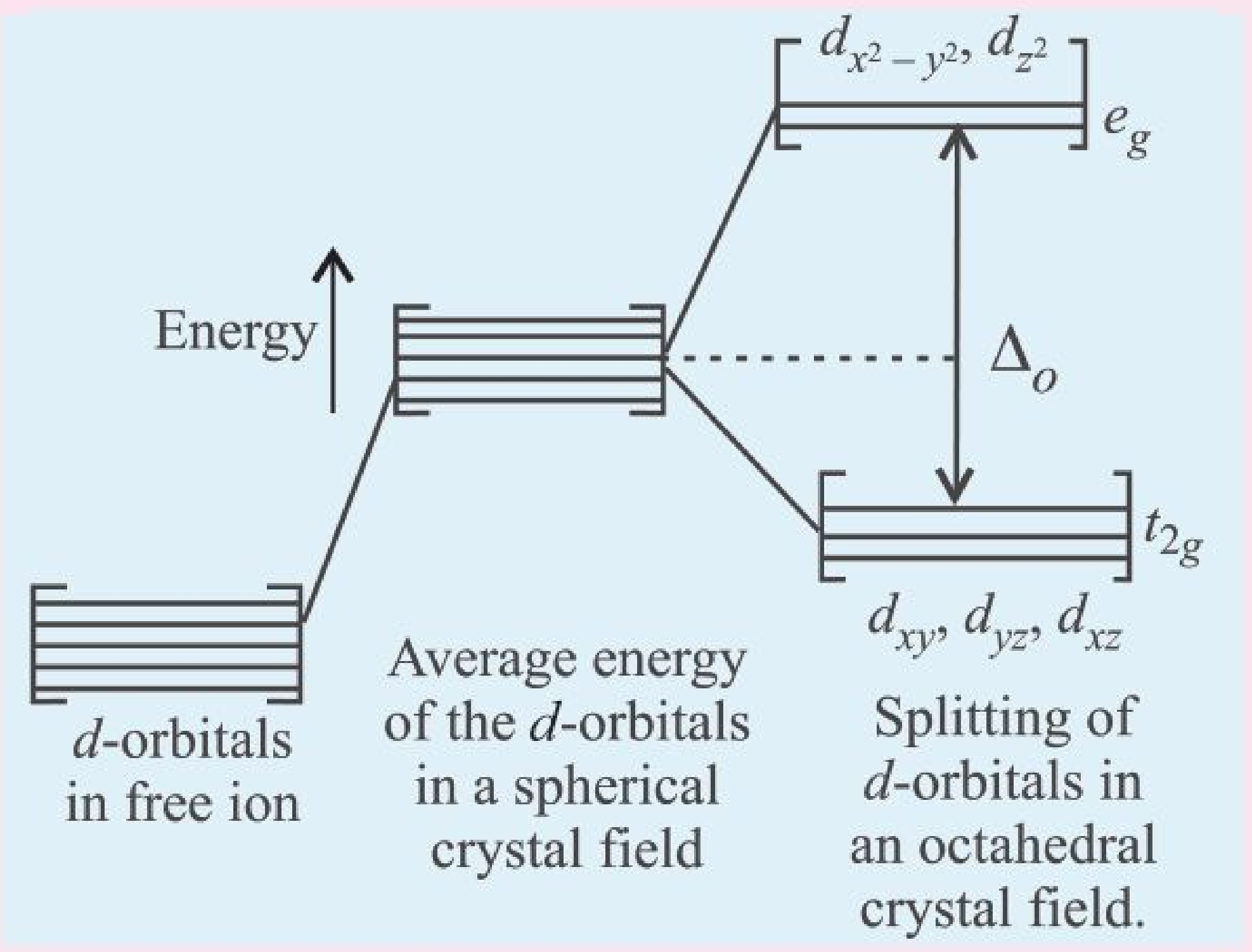
VALENCE BOND THEORY

Inner orbital complexes	Outer orbital complexes
Involves inner *d*-orbitals *i.e.*, $(n-1)d$-orbitals.	Involves outer *d*-orbitals *i.e.*, *nd*-orbitals.
Low spin complexes	High spin complexes
Have less or no unpaired electrons. *e.g.*, $[Co(NH_3)_6]^{3+}$, $[Co(CN)_6]^{4-}$	Have large number of unpaired electrons. *e.g.*, $[MnF_6]^{3-}$, $[CoF_6]^{3-}$

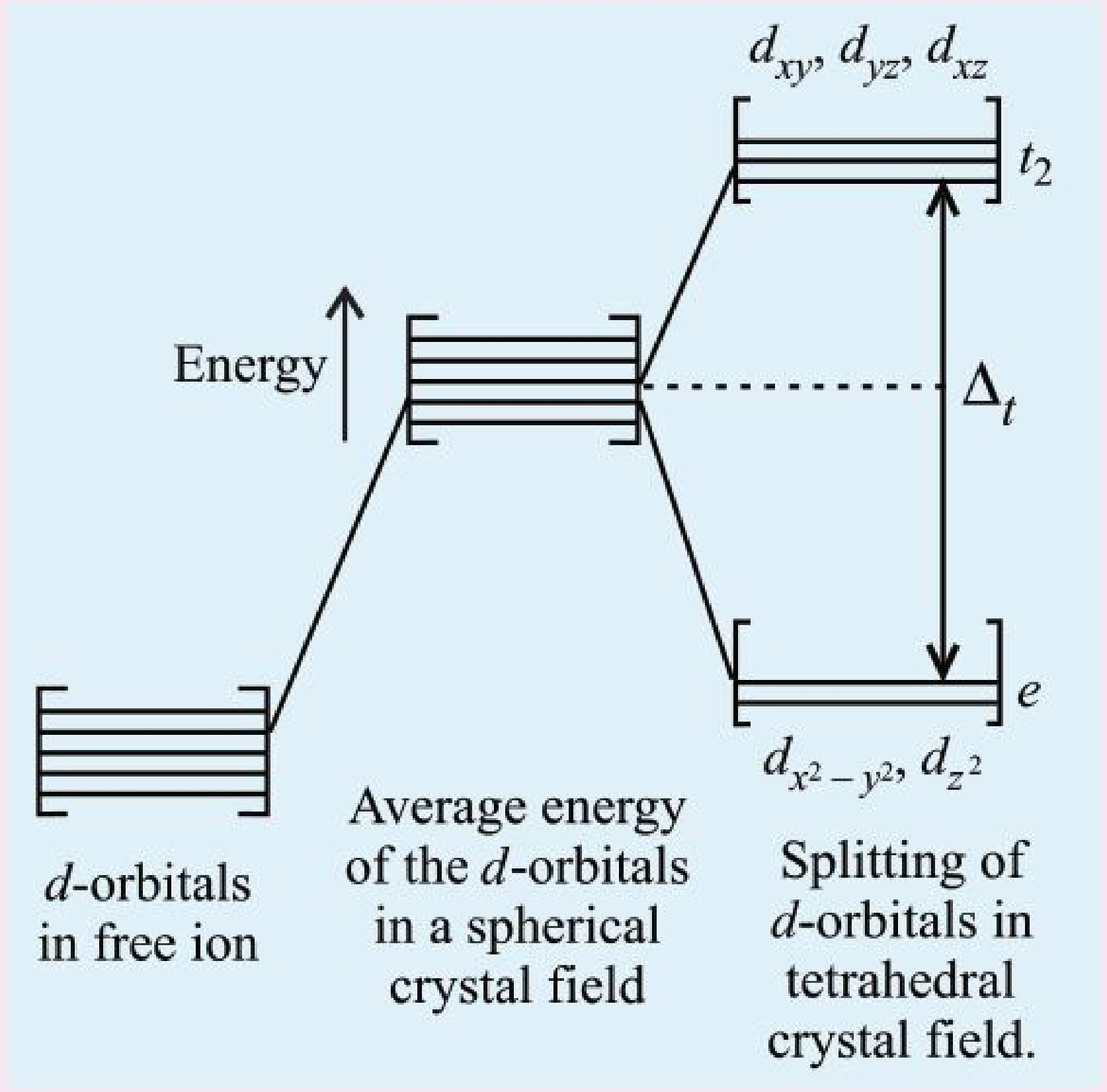
- Low spin complexes are generally diamagnetic and high spin complexes are paramagnetic.
- Paramagnetism ∝ No. of unpaired electrons.
- Magnetic moment $= \sqrt{n(n+2)}$ B.M., where n = number of unpaired electrons.

CRYSTAL FIELD THEORY

- Crystal field splitting in octahedral coordination complexes is shown as :


$d_{x^2-y^2}, d_{z^2}$
e_g
Energy
Δ_o
t_{2g}
d_{xy}, d_{yz}, d_{xz}
d-orbitals in free ion
Average energy of the d-orbitals in a spherical crystal field
Splitting of d-orbitals in an octahedral crystal field.

- If $\Delta_o < P$ (where 'P' is energy required for forced pairing of electrons), then the electrons will remain unpaired and a high spin complex is formed.
- If $\Delta_o > P$, then pairing of electrons takes place and a low spin complex is formed.
  - Crystal field splitting in tetrahedral complexes is shown as :


d_{xy}, d_{yz}, d_{xz}
t_2
Energy
Δ_t
e
$d_{x^2-y^2}, d_{z^2}$
d-orbitals in free ion
Average energy of the d-orbitals in a spherical crystal field
Splitting of d-orbitals in tetrahedral crystal field.

- Difference in energy between e and t_2 level is less in tetrahedral complexes.

$$\Delta_t = \frac{4}{9}\Delta_o$$

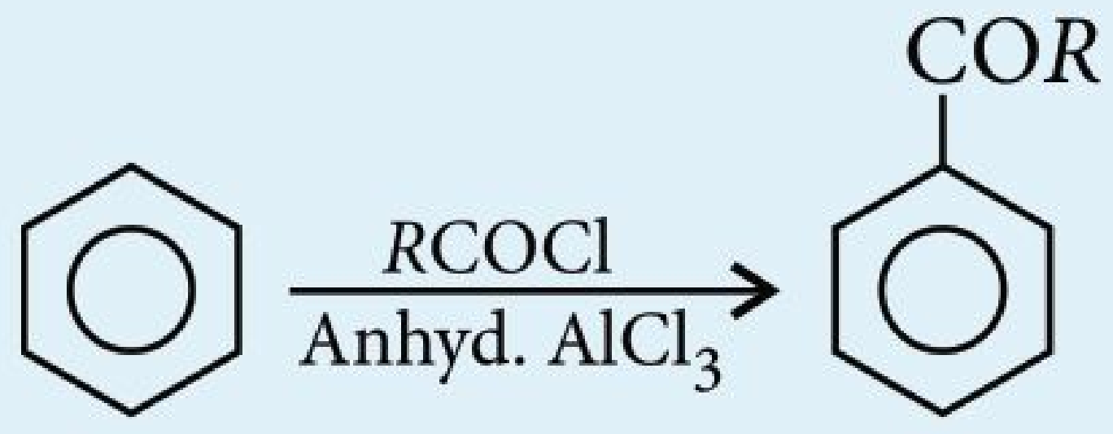
- **Spectrochemical series :** Arrangement of ligands in the order of increasing field strength.

$$\text{Weak field ligands} \xrightarrow{\text{Increasing order of CFSE } (\Delta_o)} \text{Strong field ligands}$$

$$I^- < Br^- < SCN^- < Cl^- < S^{2-} < F^- < OH^- < C_2O_4^{2-} < H_2O < NCS^- < \text{edta}^{4-} < NH_3 < en < NO_2^- < CN^- < CO$$

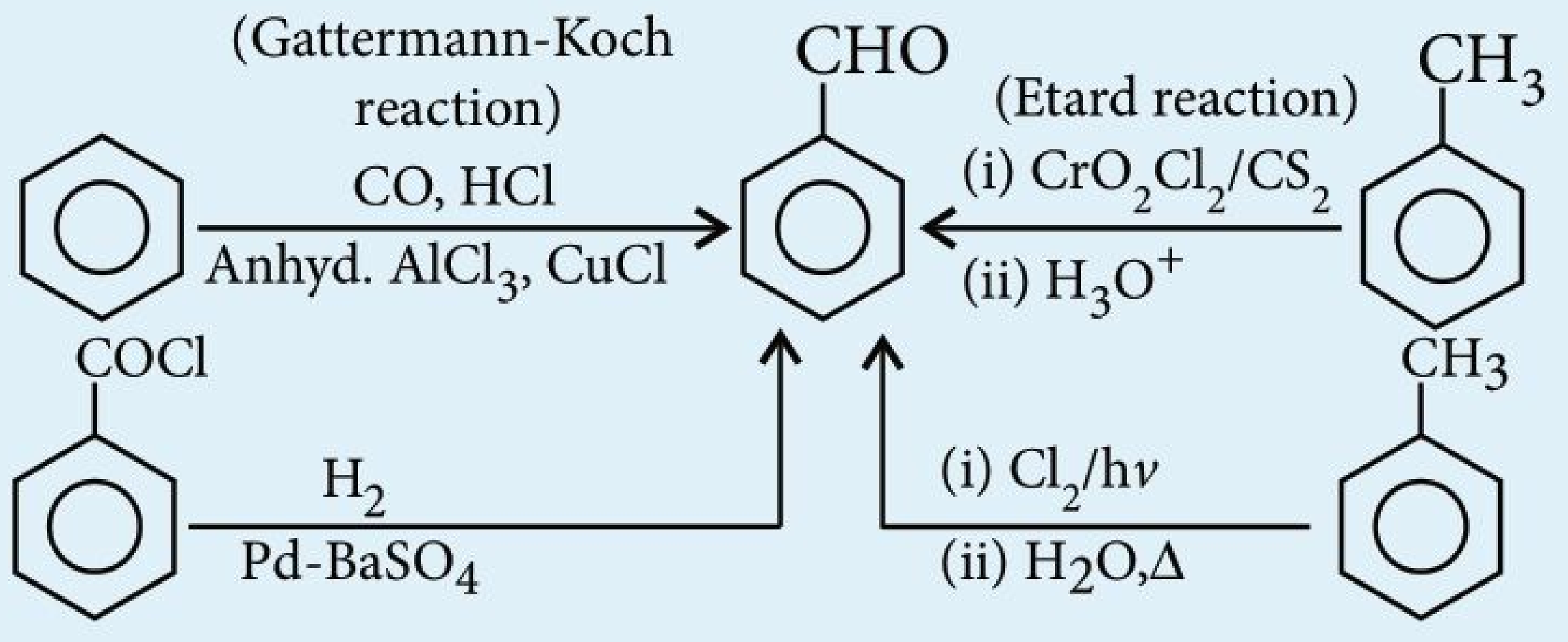
Chapter 12 : Aldehydes, Ketones and Carboxylic Acids

PREPARATION OF ALDEHYDES AND KETONES

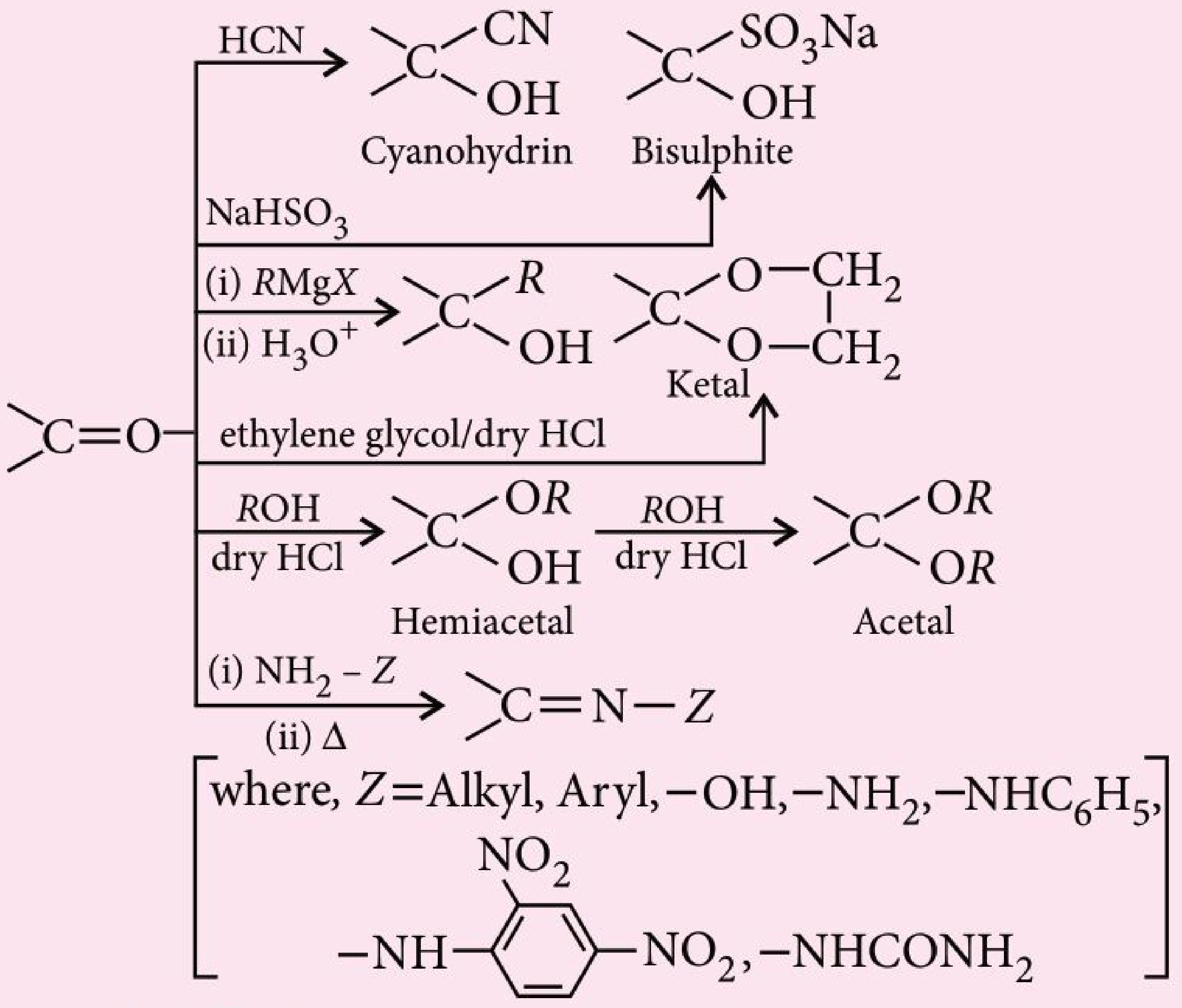
- $RCH_2OH \xrightarrow[H_2SO_4\,(\text{dil.})]{K_2Cr_2O_7} RCHO + H_2O$
- $R_2CHOH \xrightarrow[H_2SO_4\,(\text{dil.})]{K_2Cr_2O_7} R-\overset{\overset{\large O}{\|}}{C}-R + H_2O$
- $-C\equiv C- \xrightarrow[HgSO_4,\ 333\ K]{\text{dil. } H_2SO_4} RCHO \text{ or } RCOR$
- $R_2CHOH \xrightarrow[573\ K]{Cu} R_2CO + H_2\uparrow$
- $RC\equiv N \xrightarrow[\text{(ii) } H_3O^+]{\text{(i) } R'MgX/\text{dry ether}} RCOR'$
- 
COR
RCOCl
Anhyd. AlCl$_3$
- $\underset{\text{(ozonolysis)}}{RCH{=}CHR} \xrightarrow[\text{(ii) } Zn/H_2O]{\text{(i)}O_3} 2RCHO + ZnO$

-
$$\left.\begin{array}{r} RCH_2OH \xrightarrow[573\ K]{Cu} \\ RC\equiv N \xrightarrow[\text{(ii) } H_2O]{\text{(i) } AlH(i\text{-}Bu)_2} \\ RCOOR \xrightarrow[\text{(ii) } H_2O]{\text{(i) DIBAL-H, 195 K}} \\ RCOCl + H_2 \xrightarrow[\text{boiling xylene}]{Pd\text{-}BaSO_4,\ S} \\ RC\equiv N \xrightarrow[\text{Dry ether}]{\text{(i) } SnCl_2 + HCl} \end{array}\right| \rightarrow RCHO$$

(ii) H_3O^+
(Stephen reduction)

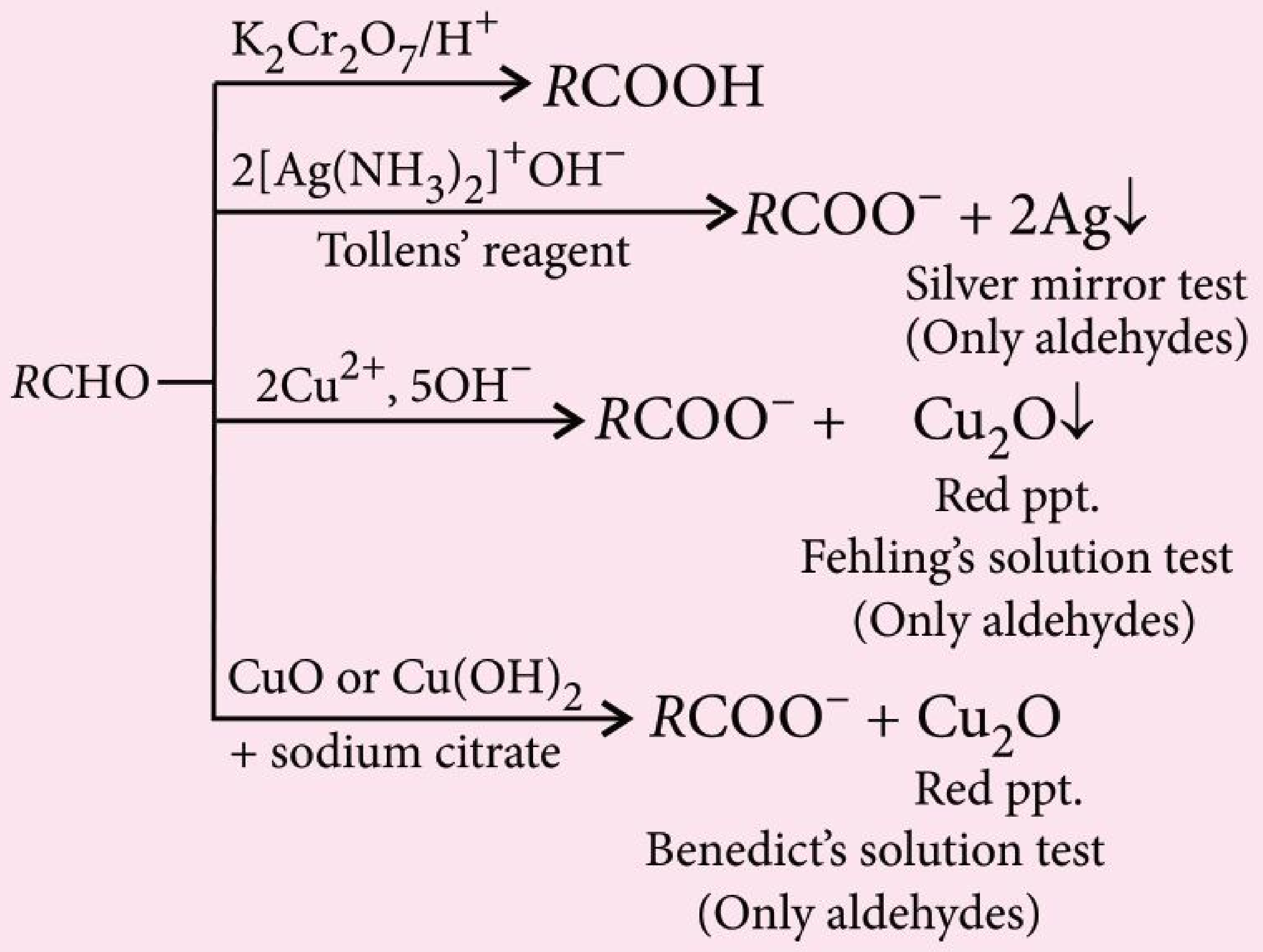
- 
(Gattermann-Koch reaction)
CO, HCl
Anhyd. AlCl$_3$, CuCl
CHO
(Etard reaction)
(i) CrO$_2$Cl$_2$/CS$_2$
(ii) H$_3$O$^+$
CH$_3$
COCl
H$_2$
Pd-BaSO$_4$
(i) Cl$_2$/$h\nu$
(ii) H$_2$O,Δ
CH$_3$

CHEMICAL PROPERTIES



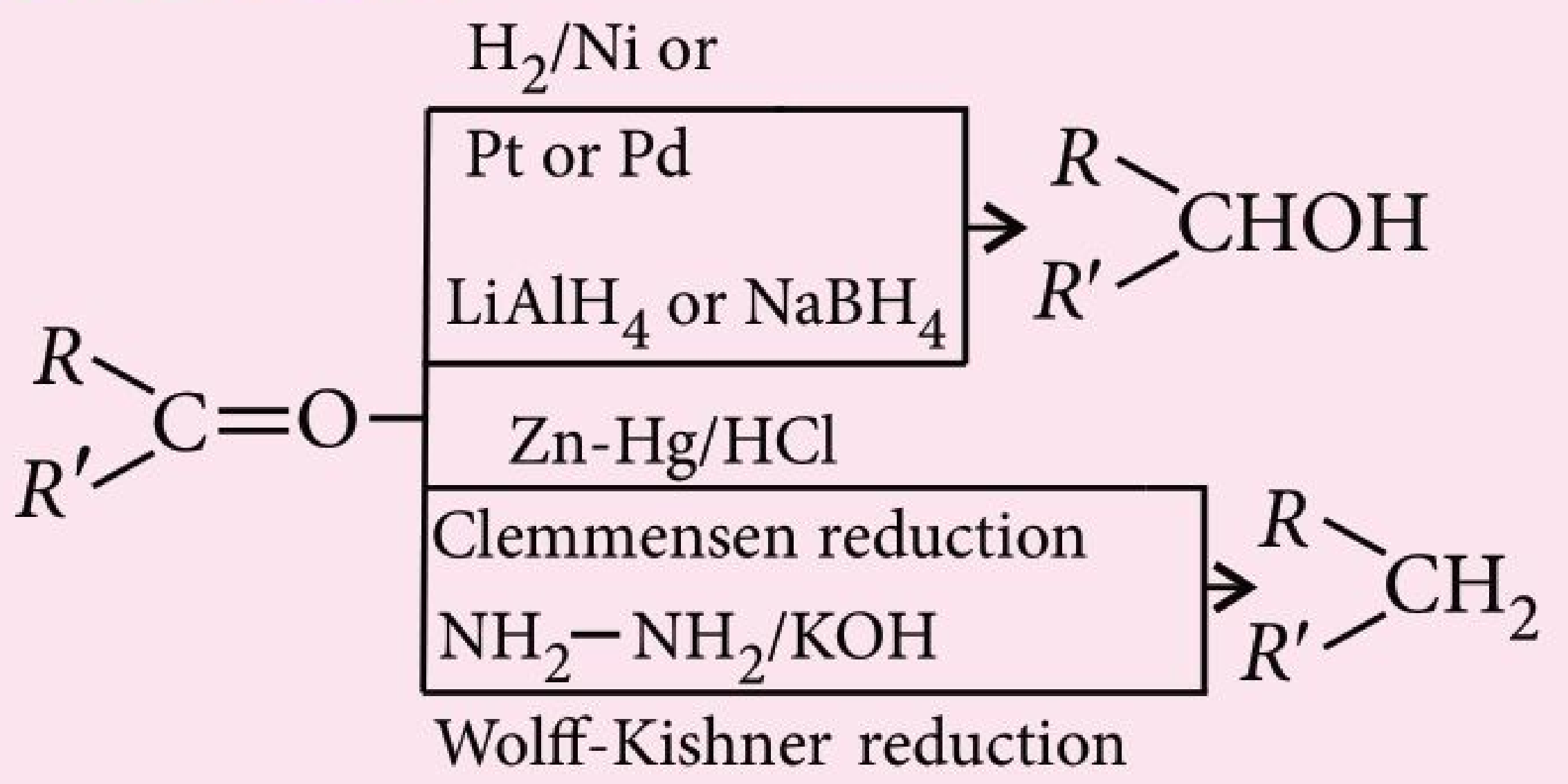
>C=O
HCN
Cyanohydrin
NaHSO3
Bisulphite
(i) RMgX
(ii) H3O+
Ketal
ethylene glycol/dry HCl
ROH
dry HCl
Hemiacetal
Acetal
(i) NH2 – Z
(ii) Δ
>C=N–Z
where, Z=Alkyl, Aryl, –OH, –NH2, –NHC6H5,
NO2
–NH–
–NO2, –NHCONH2

- **Oxidation :**



RCHO
K2Cr2O7/H+
RCOOH
2[Ag(NH3)2]+OH−
Tollens' reagent
RCOO− + 2Ag↓
Silver mirror test
(Only aldehydes)
2Cu2+, 5OH−
RCOO− + Cu2O↓
Red ppt.
Fehling's solution test
(Only aldehydes)
CuO or Cu(OH)2
+ sodium citrate
RCOO− + Cu2O
Red ppt.
Benedict's solution test
(Only aldehydes)

- **Reduction :**



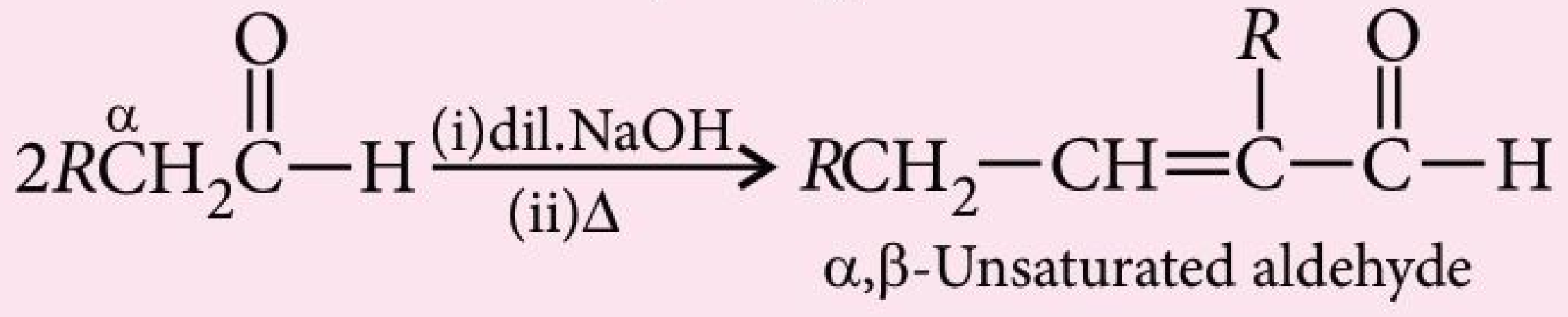
R
R′
C=O
H2/Ni or
Pt or Pd
LiAlH4 or NaBH4
CHOH
Zn-Hg/HCl
Clemmensen reduction
NH2–NH2/KOH
Wolff-Kishner reduction
CH2

- **Haloform reaction :** Given by methyl ketone

$$RCOCH_3 + 3NaOI \longrightarrow RCOONa + CHI_3\downarrow + 2NaOH$$

Iodoform (yellow ppt.)

- **Aldol condensation :** Given by aldehydes and ketones with α–hydrogen.



$$2R\overset{\alpha}{C}H_2\overset{O}{\overset{\|}{C}}-H \xrightarrow[(ii)\Delta]{(i)dil.NaOH} RCH_2-CH=\overset{R}{\overset{|}{C}}-\overset{O}{\overset{\|}{C}}-H$$

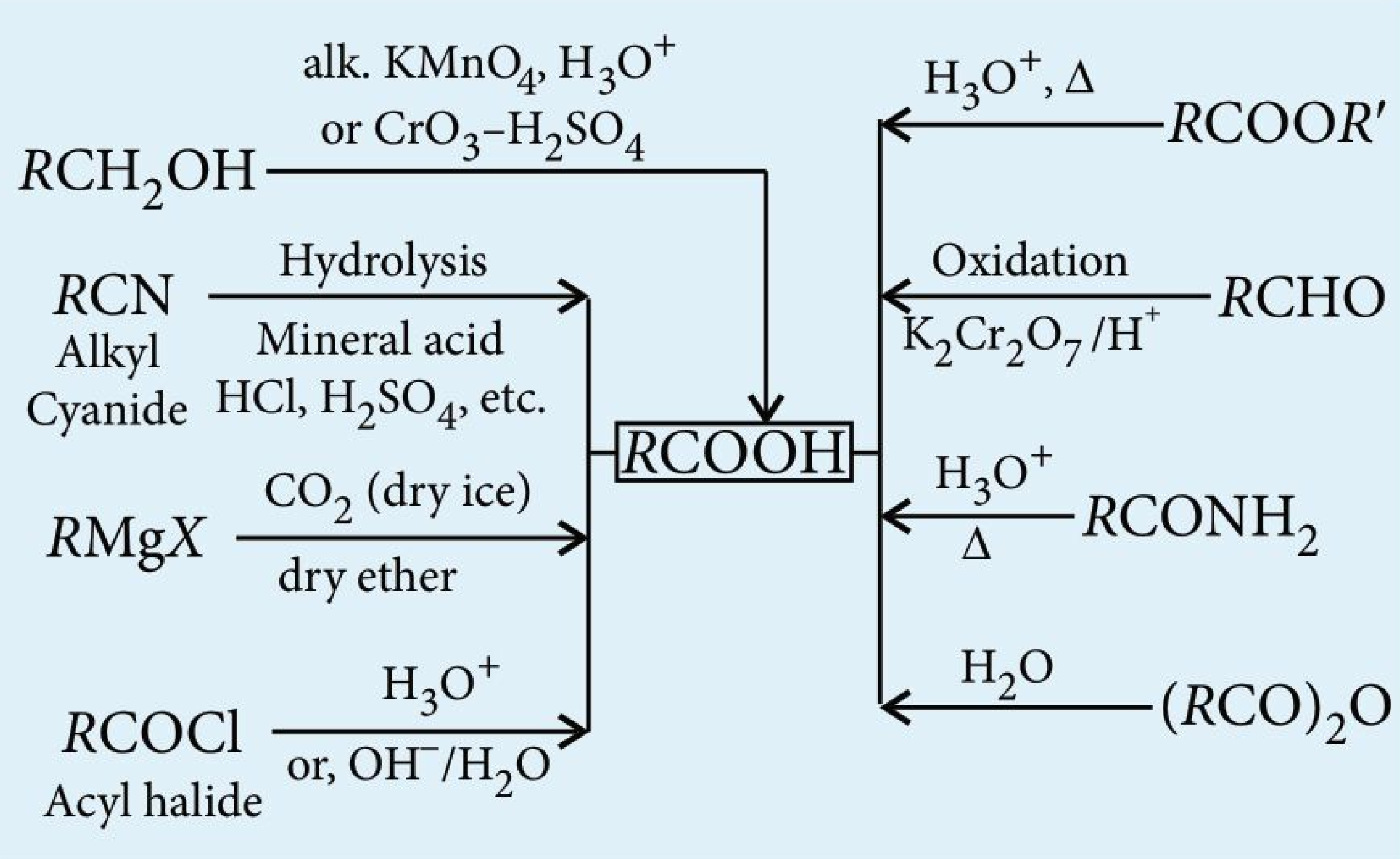
α,β-Unsaturated aldehyde

- **Cannizzaro reaction :** Given by aldehydes which do not have α–hydrogen.

$$HCHO + HCHO \xrightarrow{conc.\ KOH} CH_3OH + HCO\overset{-}{O}\overset{+}{K}$$

Formaldehyde — Methanol — Potassium formate

PREPARATION OF CARBOXYLIC ACIDS

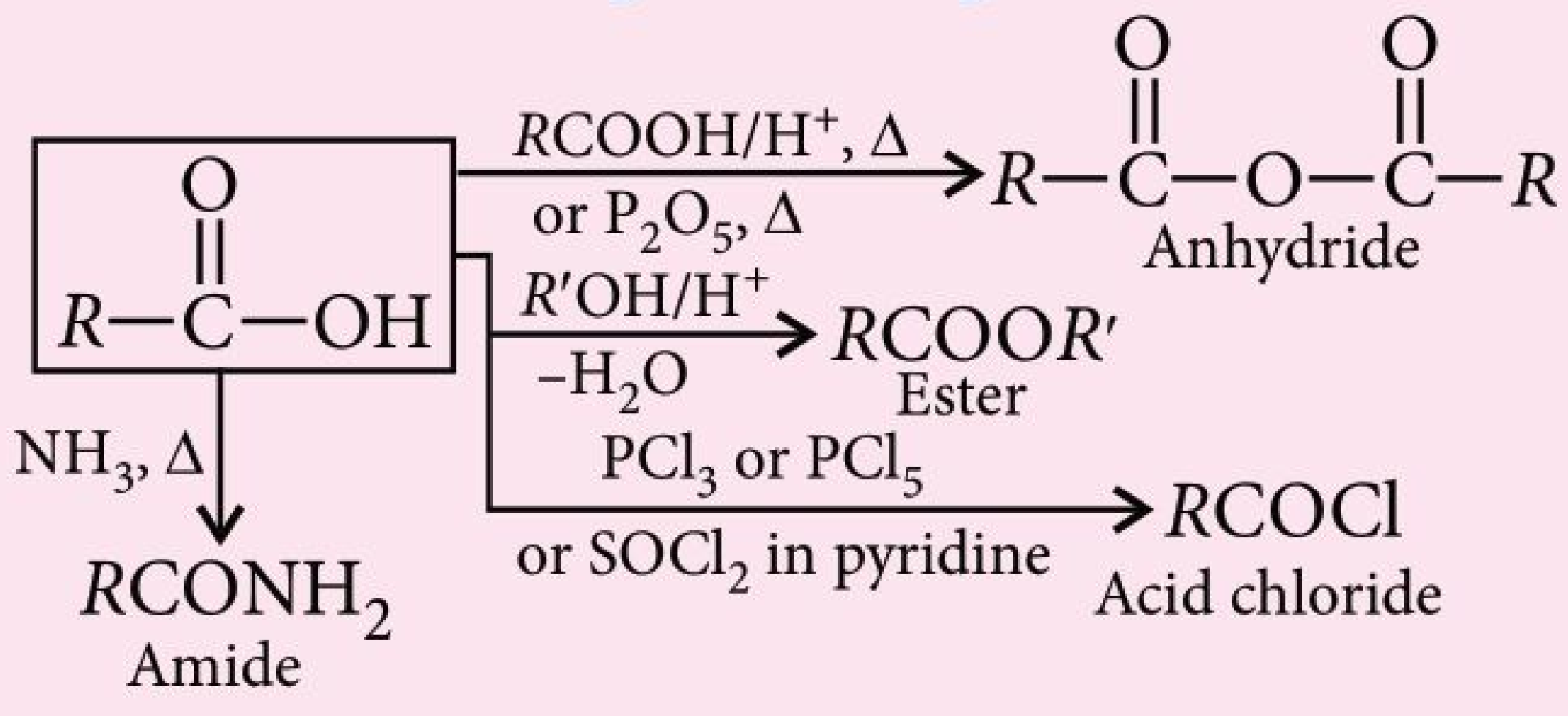


RCH2OH
alk. KMnO4, H3O+
or CrO3–H2SO4
RCN
Alkyl
Cyanide
Hydrolysis
Mineral acid
HCl, H2SO4, etc.
RMgX
CO2 (dry ice)
dry ether
RCOCl
Acyl halide
H3O+
or, OH−/H2O
RCOOH
H3O+, Δ
RCOOR′
Oxidation
K2Cr2O7/H+
RCHO
H3O+
Δ
RCONH2
H2O
(RCO)2O

CHEMICAL PROPERTIES

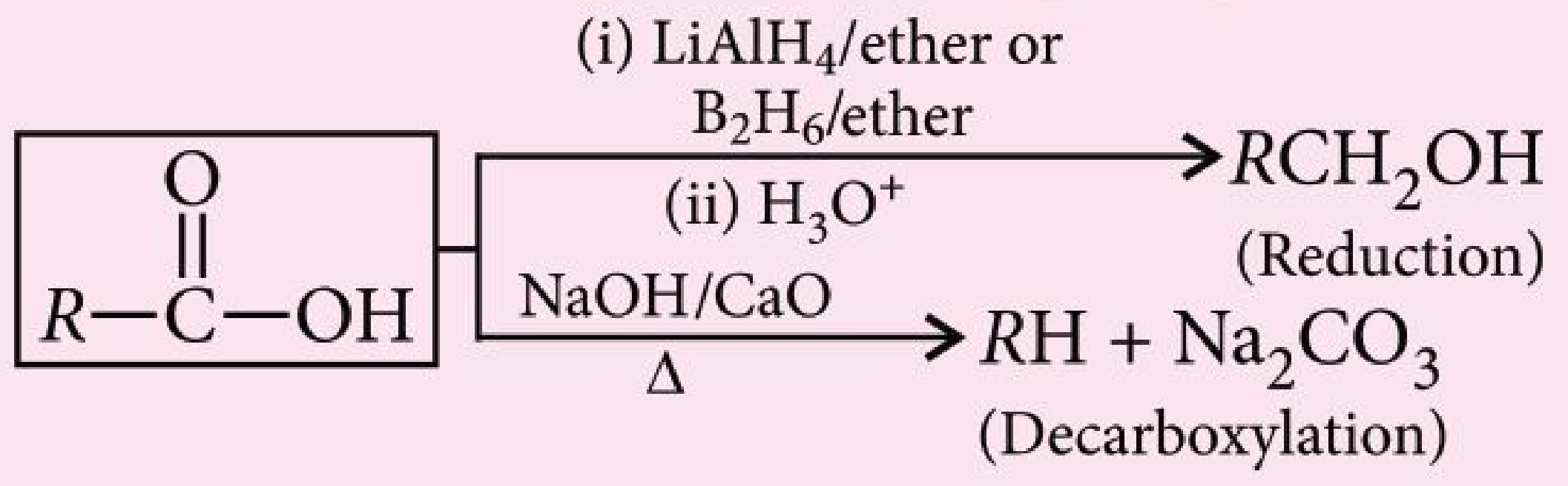
- Carboxylic acids are weaker acids than mineral acids but stronger acids than phenols and alcohols.
  - Electron withdrawing groups (EWG) increase the acidity of carboxylic acids by stabilising the conjugate base through delocalisation of negative charge by inductive and/or resonance effects.
  - Electron donating groups (EDG) decrease the acidity by destabilising the conjugate base, *e.g.*, formic acid is stronger acid than acetic acid.

Reactions Involving Cleavage of C—OH bond



R–C(=O)–OH
RCOOH/H+, Δ
or P2O5, Δ
R–C(=O)–O–C(=O)–R
Anhydride
R′OH/H+
–H2O
RCOOR′
Ester
PCl3 or PCl5
or SOCl2 in pyridine
RCOCl
Acid chloride
NH3, Δ
RCONH2
Amide

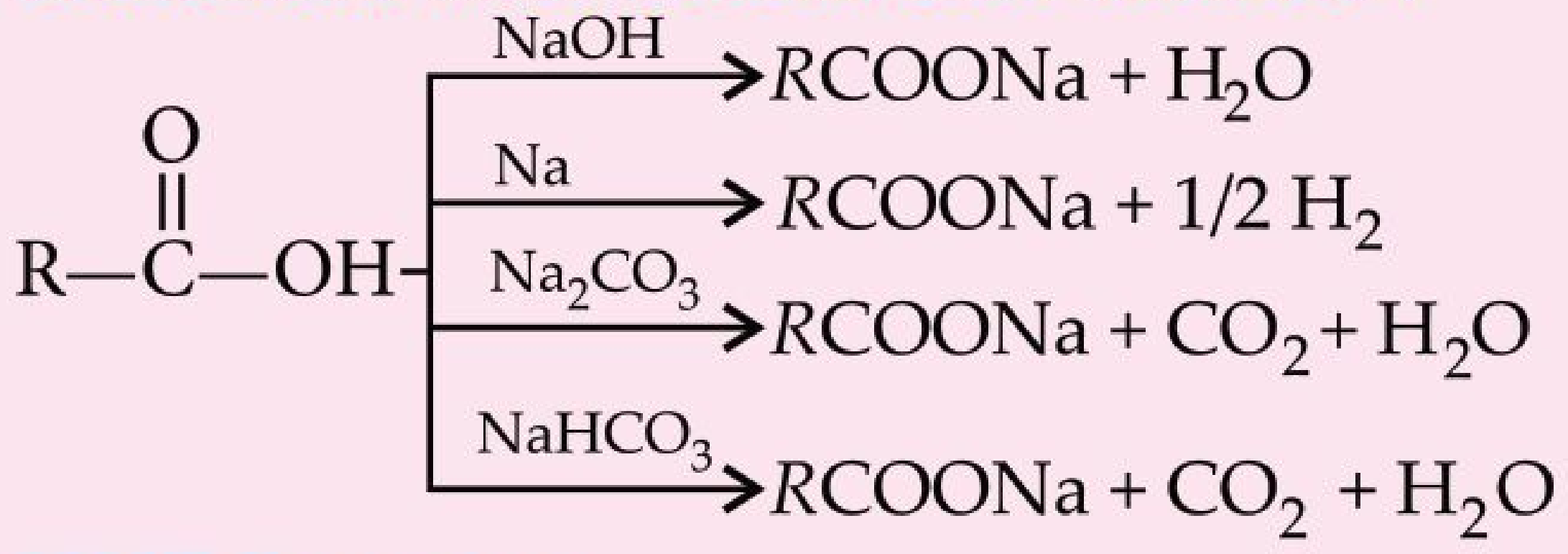
Reaction involving —COOH group



R–C(=O)–OH
(i) LiAlH4/ether or
B2H6/ether
(ii) H3O+
RCH2OH
(Reduction)
NaOH/CaO
Δ
RH + Na2CO3
(Decarboxylation)

Reactions Involving Cleavage of O—H Bond

- **Reactions with metals and alkalies :**

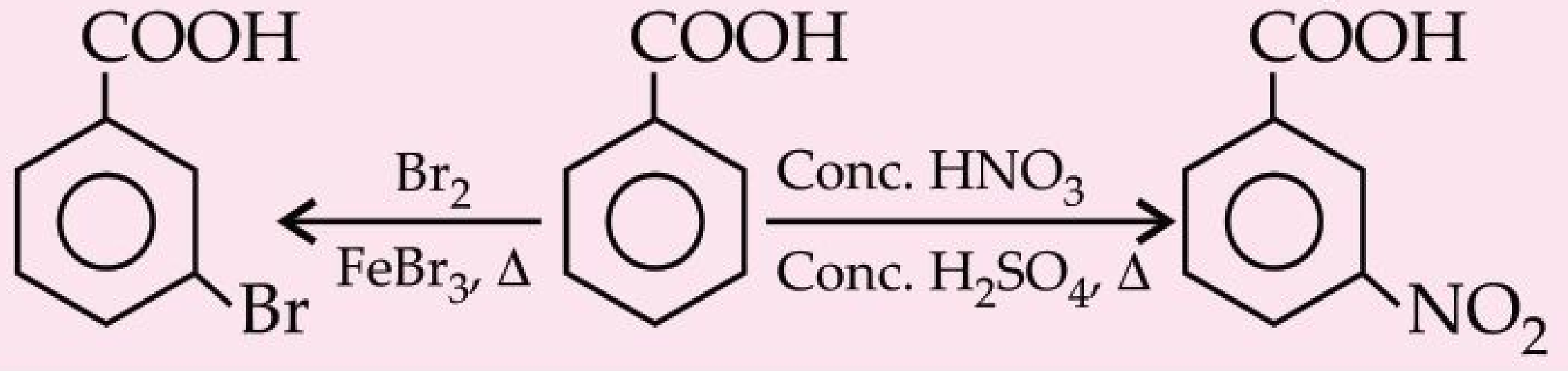


R–C(=O)–OH
NaOH
RCOONa + H2O
Na
RCOONa + 1/2 H2
Na2CO3
RCOONa + CO2 + H2O
NaHCO3
RCOONa + CO2 + H2O

- **HVZ Reaction**

$$RCH_2COOH \xrightarrow[(ii)\ H_2O]{(i)\ X_2/Red\ P} R-CHX-COOH$$

α-Halocarboxylic acid

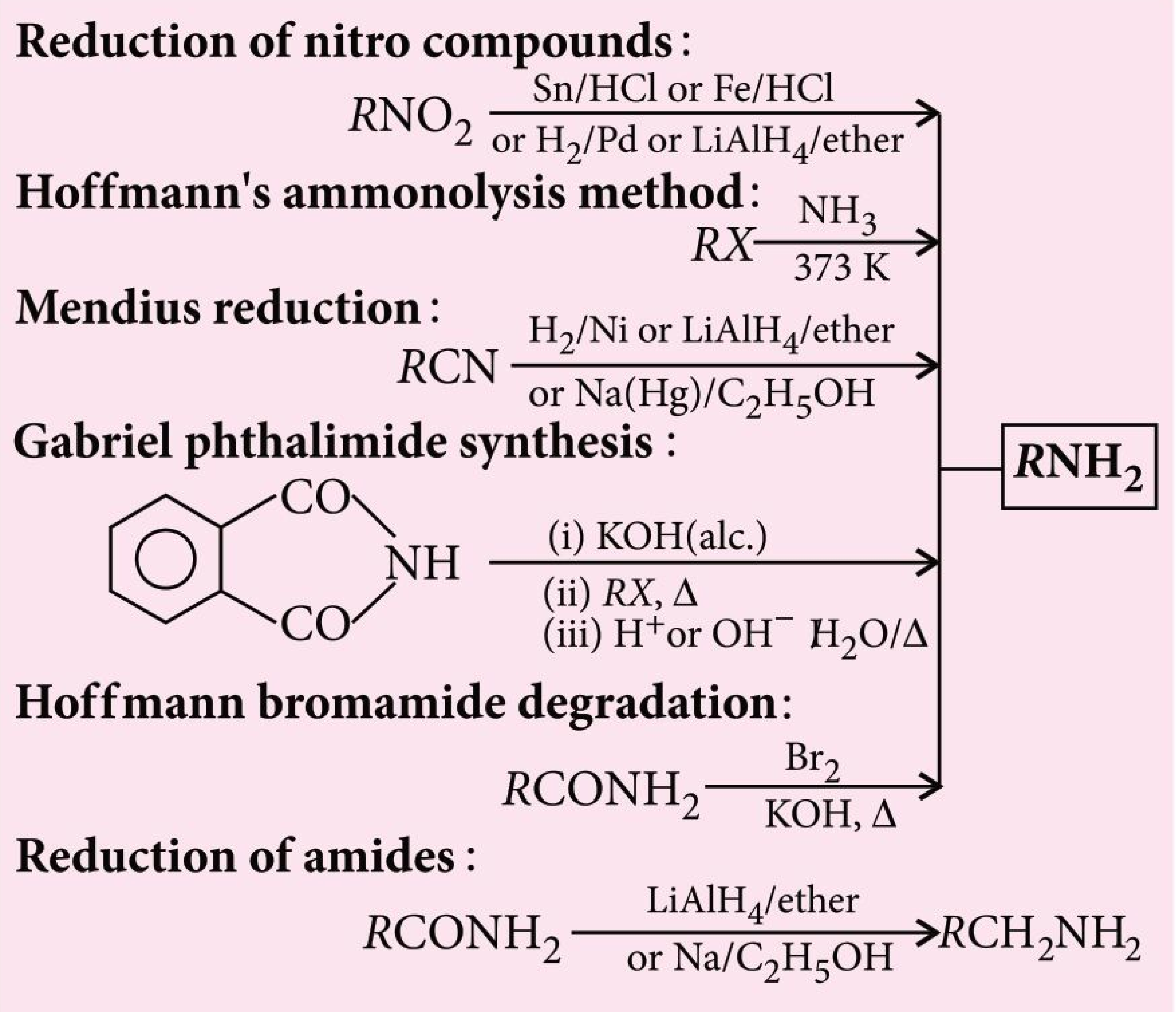


COOH
Br
Br2
FeBr3, Δ
COOH
Conc. HNO3
Conc. H2SO4, Δ
COOH
NO2

Chapter 13 : Amines

Amines are the derivatives of ammonia where one or more H-atoms have been replaced by carbon chain or ring.

PREPARATION OF AMINES

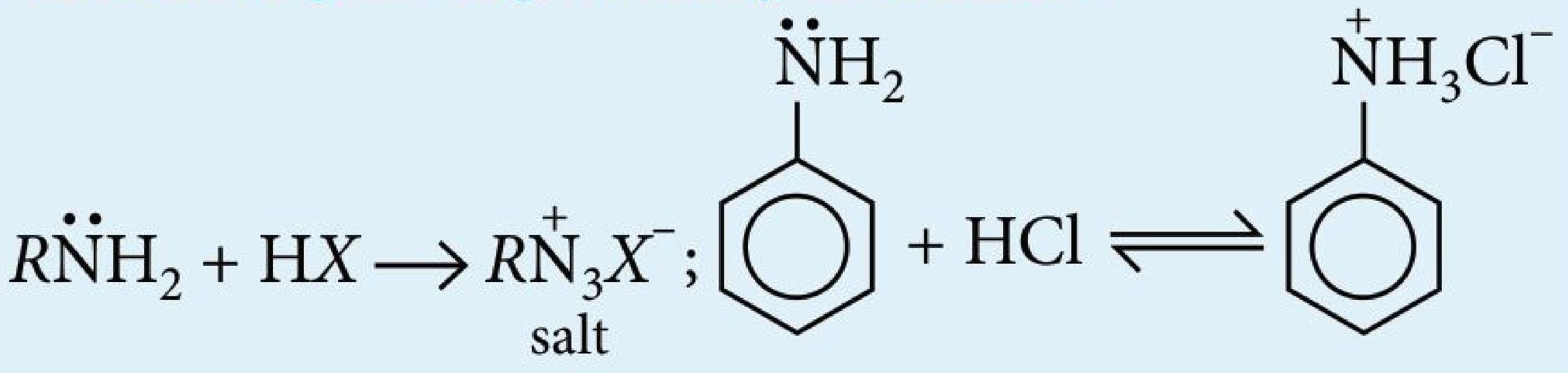

Reduction of nitro compounds :
RNO_2
Sn/HCl or Fe/HCl
or H_2/Pd or $LiAlH_4$/ether
Hoffmann's ammonolysis method :
RX
NH_3
373 K
Mendius reduction :
RCN
H_2/Ni or $LiAlH_4$/ether
or Na(Hg)/C_2H_5OH
Gabriel phthalimide synthesis :
CO
NH
CO
(i) KOH(alc.)
(ii) RX, Δ
(iii) H^+ or OH^- H_2O/Δ
Hoffmann bromamide degradation:
$RCONH_2$
Br_2
KOH, Δ
RNH_2
Reduction of amides :
$RCONH_2$
$LiAlH_4$/ether
or Na/C_2H_5OH
RCH_2NH_2

CHEMICAL PROPERTIES

Basic character of amines : Aliphatic amines are stronger bases than ammonia due to $+I$ effect of alkyl groups present in amines.

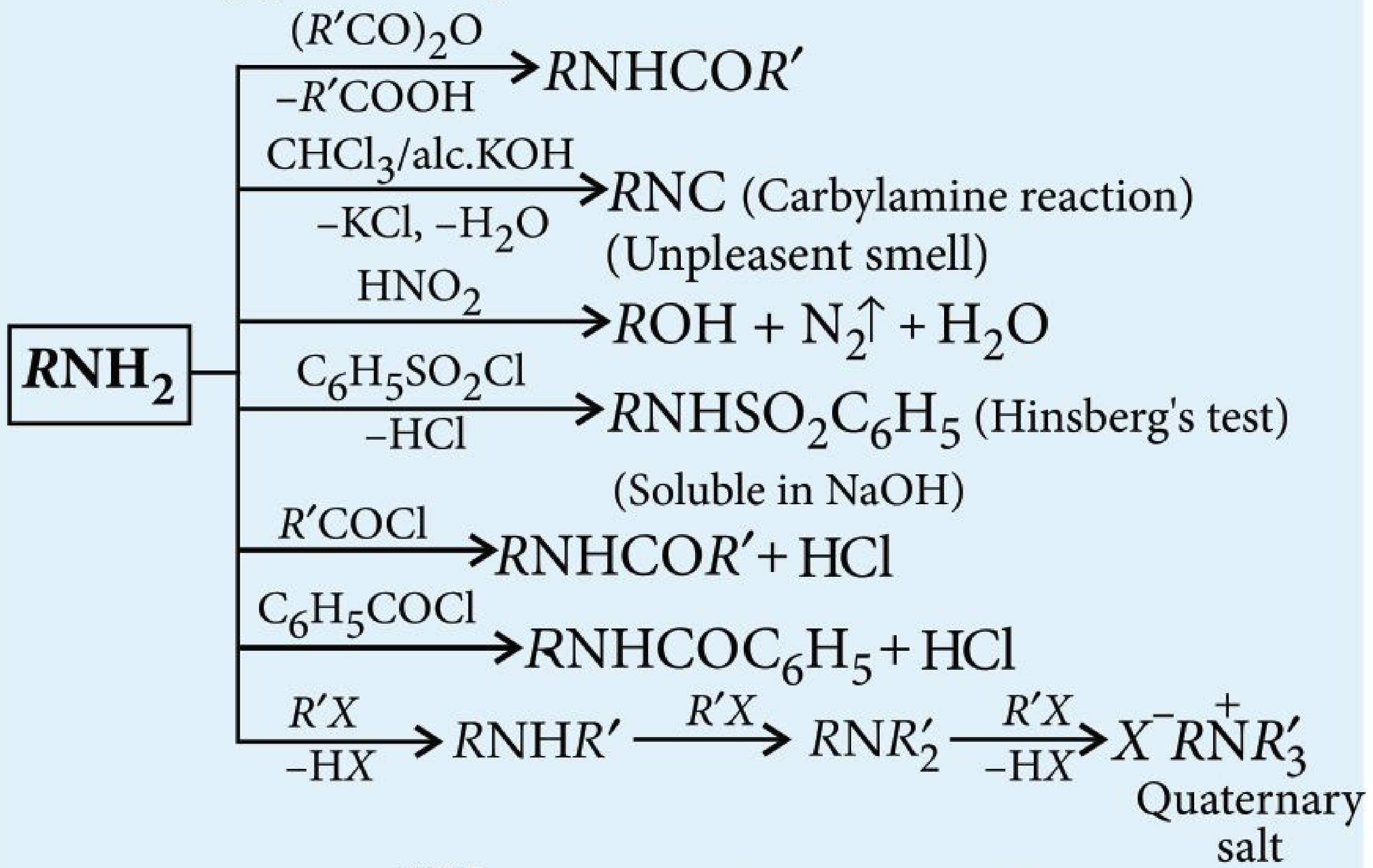
Basicity order : Aliphatic amine > NH_3 > aromatic amines

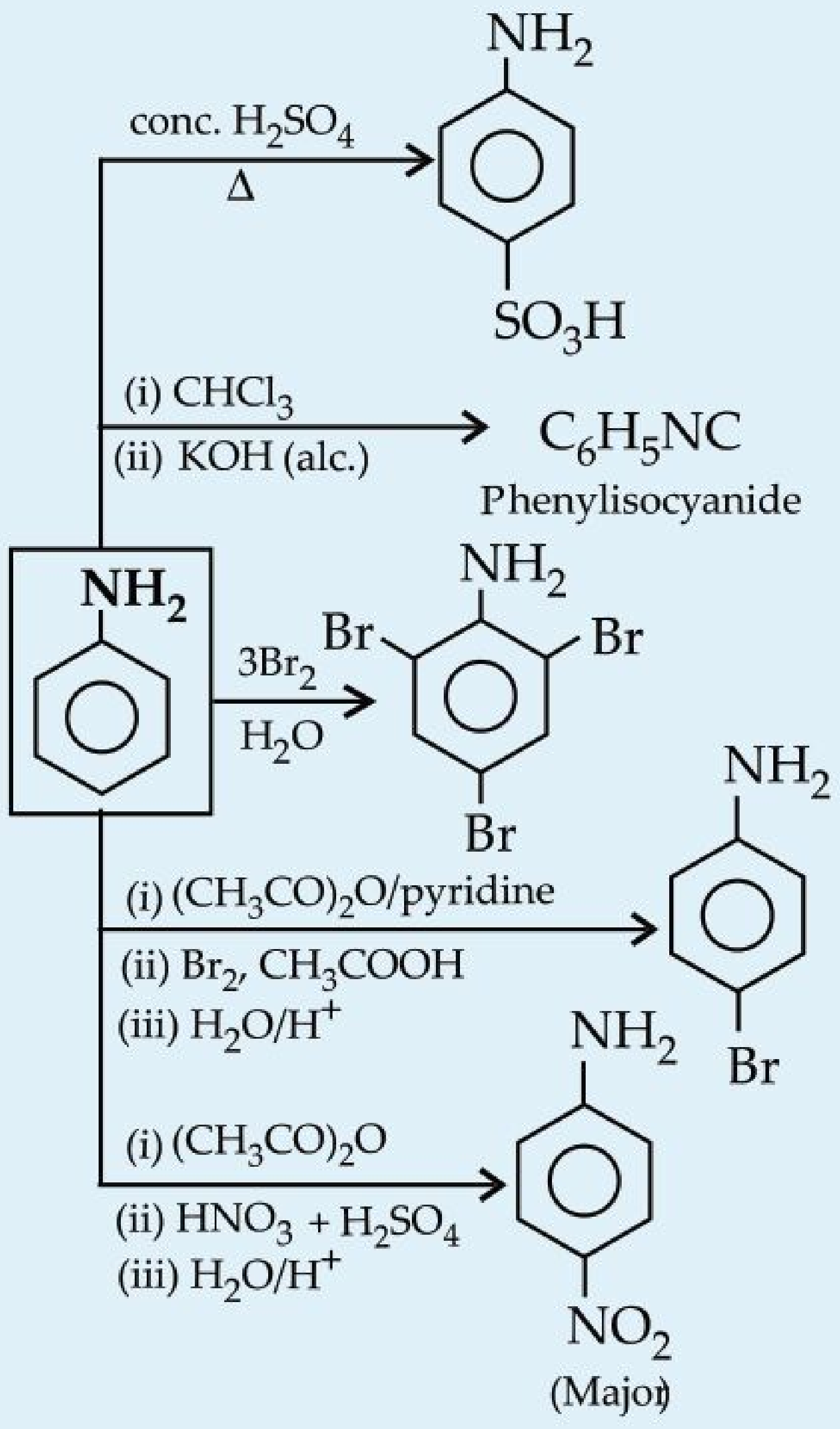
Reaction proving basicity of amines :


$R\ddot{N}H_2 + HX \longrightarrow R\overset{+}{N}H_3\overset{-}{X}$;
salt
$\ddot{N}H_2$
+ HCl ⇌
$\overset{+}{N}H_3\overset{-}{Cl}$

In gaseous phase, the order of basicity of amines is 3° amine > 2° amine > 1° amine > NH_3.

In aqueous phase, $(C_2H_5)_2NH > (C_2H_5)_3N > C_2H_5NH_2 > NH_3$ and $(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > NH_3$


RNH_2
$(R'CO)_2O$
$-R'COOH$
$RNHCOR'$
$CHCl_3$/alc.KOH
$-KCl, -H_2O$
RNC (Carbylamine reaction)
(Unpleasant smell)
HNO_2
$ROH + N_2\uparrow + H_2O$
$C_6H_5SO_2Cl$
$-HCl$
$RNHSO_2C_6H_5$ (Hinsberg's test)
(Soluble in NaOH)
$R'COCl$
$RNHCOR' + HCl$
C_6H_5COCl
$RNHCOC_6H_5 + HCl$
$R'X$
$-HX$
$RNHR'$
$R'X$
RNR'_2
$R'X$
$-HX$
$\overset{-}{X}\overset{+}{R}NR'_3$
Quaternary salt

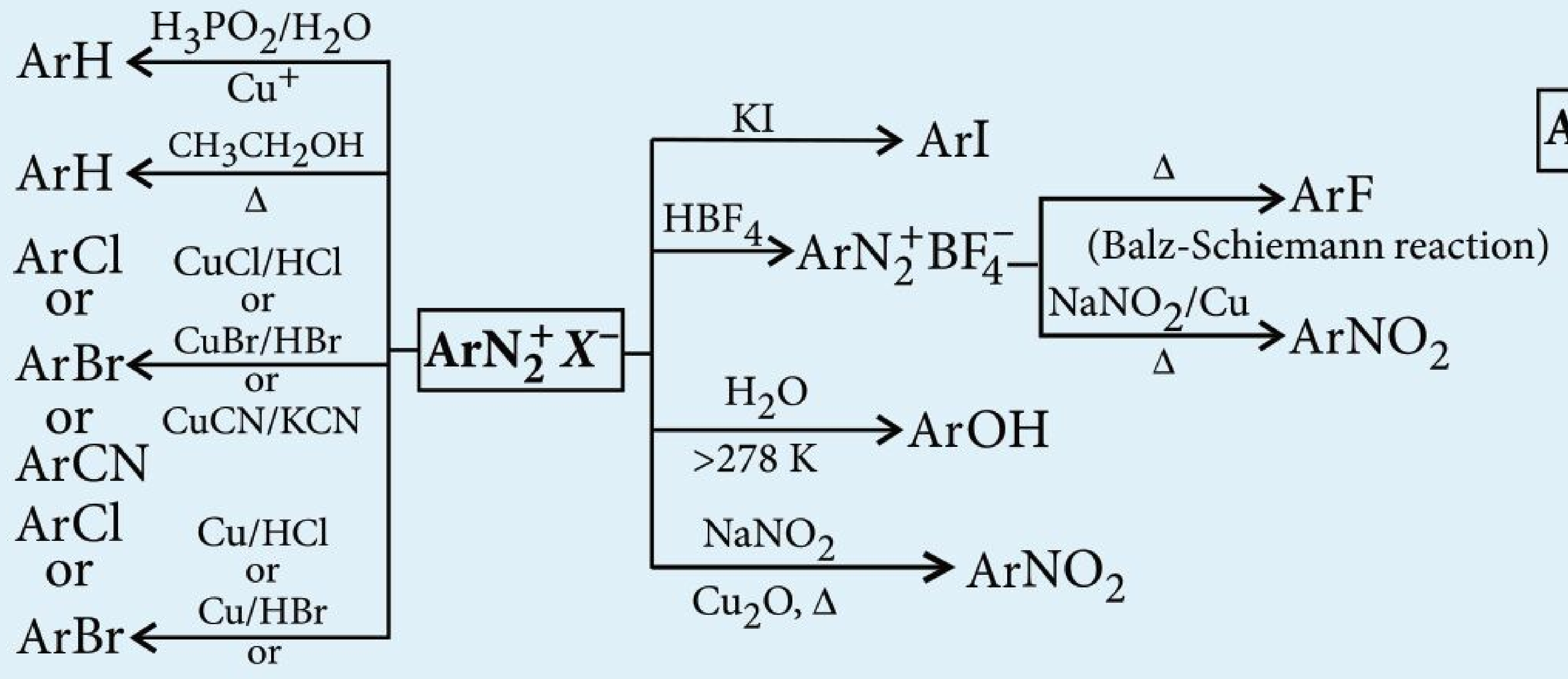

NH_2
conc. H_2SO_4
Δ
SO_3H
(i) $CHCl_3$
(ii) KOH (alc.)
C_6H_5NC
Phenylisocyanide
$3Br_2$
H_2O
Br
Br
Br
(i) $(CH_3CO)_2O$/pyridine
(ii) Br_2, CH_3COOH
(iii) H_2O/H^+
Br
(i) $(CH_3CO)_2O$
(ii) $HNO_3 + H_2SO_4$
(iii) H_2O/H^+
NO_2
(Major)

Electrophilic substitution reactions of arylamines: Aniline undergoes electrophilic substitution reactions. $-NH_2$ is *ortho-* and *para-*directing and a powerful activating group.

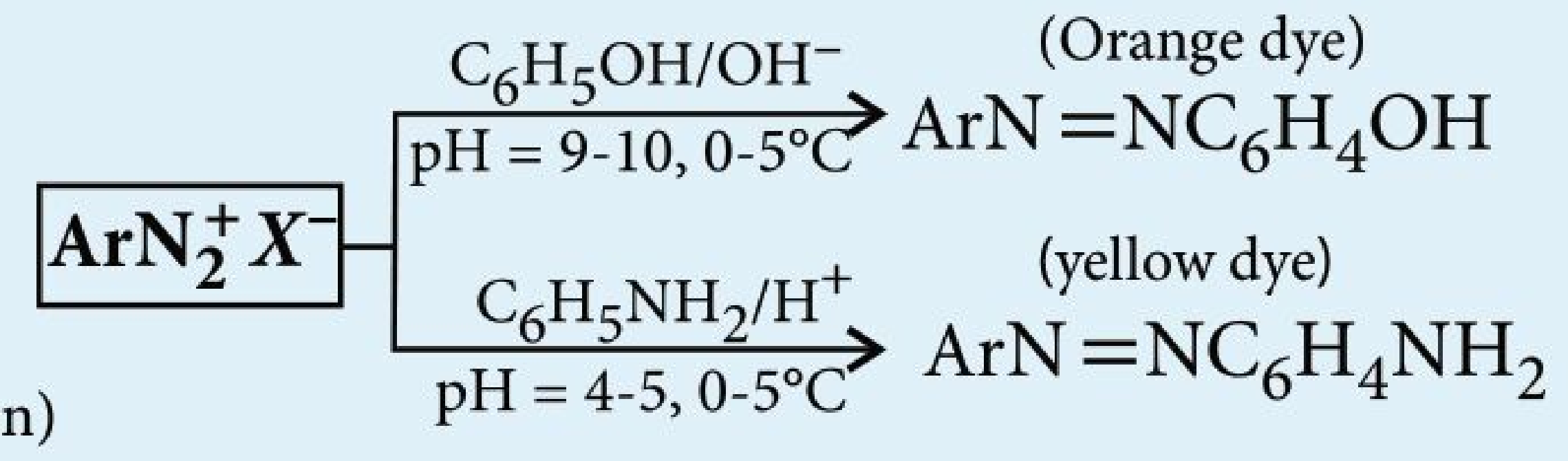
Diazonium salts : Benenediazonium chloride is prepared by the reaction of aniline with nitrous acid.

$$C_6H_5NH_2 + HNO_2 \xrightarrow{0-5\,°C} C_6H_5N_2^+Cl^- + NaCl + 2H_2O$$

Reactions involving displacement of nitrogen (diazo group) :


$ArN_2^+X^-$
ArH
H_3PO_2/H_2O
Cu^+
ArH
CH_3CH_2OH
Δ
ArCl or ArBr or ArCN
CuCl/HCl
or
CuBr/HBr
or
CuCN/KCN
ArCl or ArBr
Cu/HCl
or
Cu/HBr
or
KI
ArI
HBF_4
$ArN_2^+BF_4^-$
Δ
ArF
(Balz-Schiemann reaction)
$NaNO_2$/Cu
Δ
$ArNO_2$
H_2O
>278 K
ArOH
$NaNO_2$
Cu_2O, Δ
$ArNO_2$

Reactions involving retention of diazo group (coupling reactions) :


$ArN_2^+X^-$
C_6H_5OH/OH^-
pH = 9-10, 0-5°C
(Orange dye)
$ArN=NC_6H_4OH$
$C_6H_5NH_2/H^+$
pH = 4-5, 0-5°C
(yellow dye)
$ArN=NC_6H_4NH_2$

To be continued in next issue...

CBSE warm-up!

CLASS-XI

Chapterwise practice questions for CBSE Exams as per the latest pattern and reduced syllabus by CBSE for the academic session 2022-23.

Series-6

Hydrocarbons

Time Allowed : 3 hours
Maximum Marks : 70

GENERAL INSTRUCTIONS

Read the following instructions carefully.

- *(a) There are 35 questions in this question paper with internal choice.*
- *(b) SECTION A consists of 18 multiple-choice questions carrying 1 mark each.*
- *(c) SECTION B consists of 7 very short answer questions carrying 2 marks each.*
- *(d) SECTION C consists of 5 short answer questions carrying 3 marks each.*
- *(e) SECTION D consists of 2 case- based questions carrying 4 marks each.*
- *(f) SECTION E consists of 3 long answer questions carrying 5 marks each.*
- *(g) All questions are compulsory.*
- *(h) Use of log tables and calculators is not allowed.*

SECTION A

The following questions are multiple-choice questions with one correct answer. Each question carries 1 mark. There is no internal choice in this section.

1. Wurtz reaction is used to unite
(a) two alkyl halides
(b) two aryl halides
(c) alkyl and aryl halides
(d) two benzene units.

2. Which of the following has the lowest boiling point?
(a) 2-Methylbutane (b) 2-Methylpropane
(c) 2,2-Dimethylpropane (d) *n*-Pentane

3. 2-Bromopentane is treated with alcoholic KOH solution. What will be the major product formed in this reaction and what is the type of elimination called?
(a) Pent-1-ene, β-elimination
(b) Pent-2-ene, β-elimination
(c) Pent-1-ene, nucleophilic substitution
(d) Pent-2-ene, nucleophilic substitution

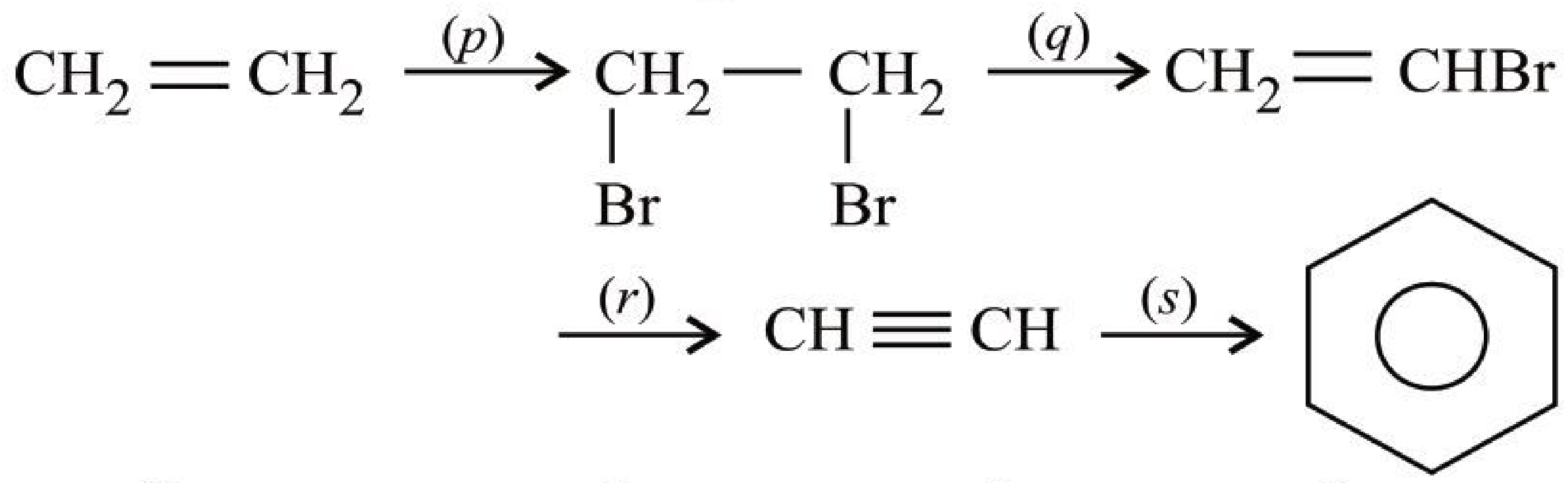
4. Which of the following products is formed when *n*-heptane is passed over ($Al_2O_3 + Cr_2O_3$) catalyst at 773 K?
(a) Benzene (b) Toluene
(c) Polyheptane (d) Cycloheptane

5. $CH_3CH_2CH_2OH \xrightarrow[170°C]{\text{conc. } H_2SO_4} A \xrightarrow[500°C]{Cl_2} B$.
Identify *A* and *B*.
(a) $A = CH_3CH_2CH_3$, $B = CH_3CH_2CH_2Cl$
(b) $A = CH_3CH{=}CH_2$, $B = CH_2ClCH{=}CH_2$
(c) $A = CH_2{=}CH_2$, $B = CH_3CH_2Cl$
(d) $A = CH_3CH_2CH_3$, $B = CH_3CH{=}CH_2$

6. What happens when calcium carbide is treated with water?
(a) Ethane is formed.
(b) Methane and ethane are formed.
(c) Ethyne is formed.
(d) Ethene and ethyne are formed.

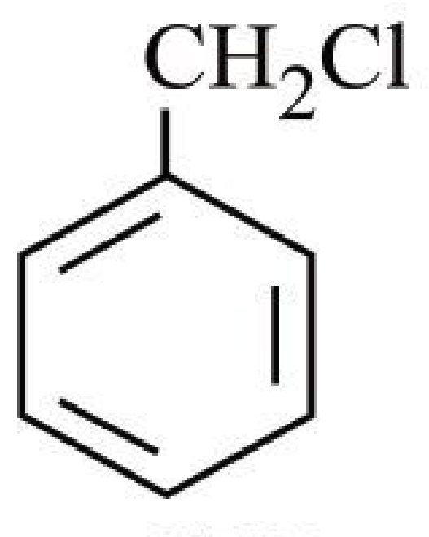
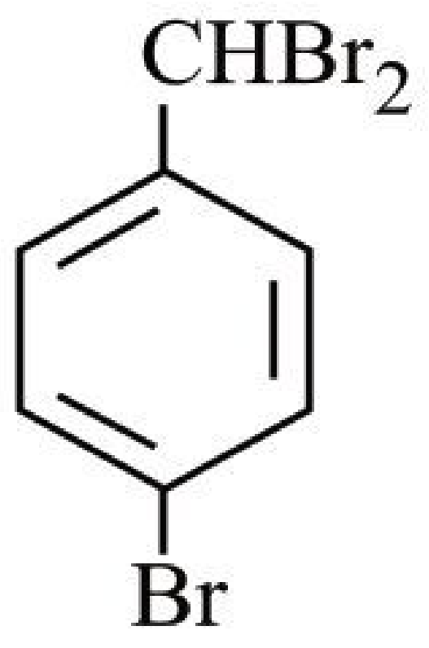
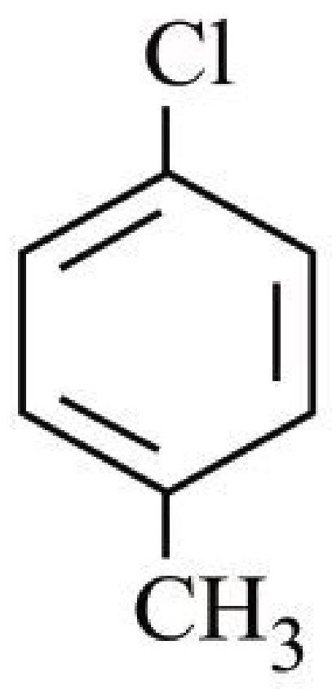
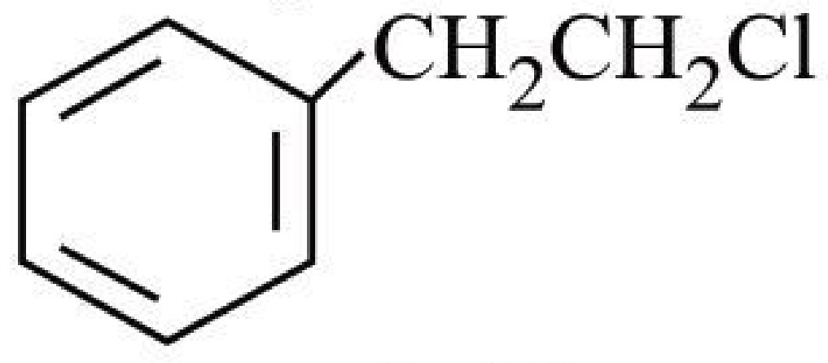
7. How many structures are possible for C_5H_8 with one triple bond?
(a) 4 (b) 3 (c) 2 (d) 1

8. Choose the correct reagents used in the conversion.



	p	*q*	*r*	*s*
(a)	Br_2	alc. KOH	NaOH	Al_2O_3
(b)	HBr	alc. KOH	CaC_2	$KMnO_4$
(c)	HBr	alc. KOH	$NaNH_2$	red hot iron tube
(d)	Br_2	alc. KOH	$NaNH_2$	red hot iron tube

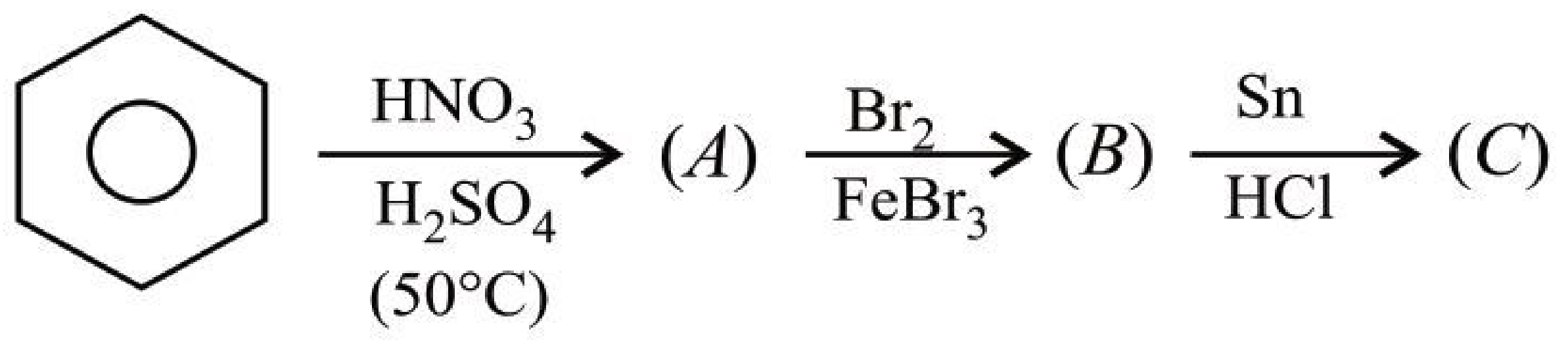
9. Which of the following names is not correctly matched with the compounds?

	Compounds	**Names**
(a)		1-Chloro-1-phenylmethane
(b)		4-Bromo-1,1-dibromo-1-phenylmethane
(c)		Chloro-4-phenylmethane
(d)		1-Chloro-2-phenylethane

10. Nitration and chlorination of benzene are
(a) nucleophilic and electrophilic substitution respectively
(b) electrophilic and nucleophilic substitution respectively
(c) electrophilic substitution reactions
(d) nucleophilic substitutions reactions.

11. Which of the following groups is *o,p* directing but deactivates benzene ring for electrophilic substitution?
(a) $-CH_3$ (b) $-NH_2$ (c) $-Cl$ (d) $-NO_2$

12. Identify (*A*), (*B*) and (*C*) in the following sequence of reactions.



(a) $A \rightarrow$ Nitrobenzene, $B \rightarrow$ Dinitrobenzene, $C \rightarrow$ *p*-Bromoaniline
(b) $A \rightarrow C_6H_5SO_3H$, $B \rightarrow$ *m*-Benzenesulphonic acid, $C \rightarrow$ *m*-Benzenesulphonate
(c) $A \rightarrow C_6H_5NO_2$, $B \rightarrow$ *m*-Bromonitrobenzene, $C \rightarrow$ *m*-Bromoaniline
(d) $A \rightarrow$ *p*-Nitrobenzene, $B \rightarrow$ *m*-Trinitrobenzene, $C \rightarrow$ *m*-Bromoaniline

13. The correct trend of acidic nature of the following alkynes is
(a) $CH{\equiv}CH > CH_3-C{\equiv}CH > CH_3C{\equiv}CCH_3$
(b) $CH_3-C{\equiv}CH > CH{\equiv}CH > CH_3C{\equiv}CCH_3$
(c) $CH_3C{\equiv}CCH_3 > CH_3-C{\equiv}CH > CH{\equiv}CH$
(d) $CH{\equiv}CH > CH_3C{\equiv}CCH_3 > CH_3C{\equiv}CH$

14. Which of the following steps is not correct in the mechanism of electrophilic substitution of benzene?
(a) Generation of electrophile like X^+, R^+, $\overset{+}{N}O_2$, etc.
(b) Attack of electrophile resulting in the formation of arenium ion in which one of the carbon is sp^3 hybridised.
(c) Addition of proton on benzene ring to give carbocation.
(d) Removal of proton from sp^3 carbon atom to restore aromatic character.

15. Given below are two statements labelled as Assertion (A) and Reason (R).
Assertion (A) : Propene reacts with HBr in presence of peroxide to give 1-bromopropane.
Reason (R) : 1° free radical is more stable than 2° free radical.
Select the most appropriate answer from the options given below :
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

16. Given below are two statements labelled as Assertion (A) and Reason (R).
Assertion (A) : *cis*-form of alkene is found to be more polar than the *trans*-form.
Reason (R) : Since the groups are in opposite directions in the *trans*-form, the dipole moments of bonds cancel each other making *trans*-form almost non-polar.
Select the most appropriate answer from the options given below :
(a) Both A and R are true and R is the correct explanation of A.

(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

17. Given below are two statements labelled as Assertion (A) and Reason (R).
Assertion (A) : Cyclopentadienyl anion is aromatic in nature.
Reason (R) : Cyclopentadienyl anion has four π electrons.
Select the most appropriate answer from the options given below :
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

18. Given below are two statements labelled as Assertion (A) and Reason (R).
Assertion (A) : Addition of HBr to propene yields 2-bromopropane but in presence of a peroxide it yields 1-bromopropane.
Reason (R) : When reaction is carried out in the presence of a peroxide it follows free radical mechanism, 2° free radical is more stable than 1° free radical.
Select the most appropriate answer from the options given below :
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

SECTION B

This section contains 7 questions with internal choice in two questions. The following questions are very short answer type and carry 2 marks each.

19. An organic compound, C_8H_{18} on monochlorination gives a single monochloride. Write the structure of the hydrocarbon.

20. Draw Newman and Sawhorse projections of ethane molecule (Eclipsed form).

OR

An alkyl bromide '*A*' forms 2, 3 - Dimethyl butane upon reaction with Na in dry ether. Determine the structure of '*A*' and write the reaction involved.

21. Arrange the following in the increasing order of boiling point :
Pentane, 2-Methylbutane, 2, 2-Dimethylpropane

22. Explain with the help of equation :
Ozonolysis of propene.

OR

Write IUPAC names of the products obtained by addition reactions of HBr to hex-1-ene:
(a) in the absence of peroxide and
(b) in the presence of peroxide.

23. Explain with example :
Acidic dehydration.

24. Which alkyne would you start with and what reagents would you use to prepare :
(a) *cis*-but-2-ene (b) *trans*-pent-2-ene ?

25. Describe a chemical test to distinguish between ethyne and ethene.

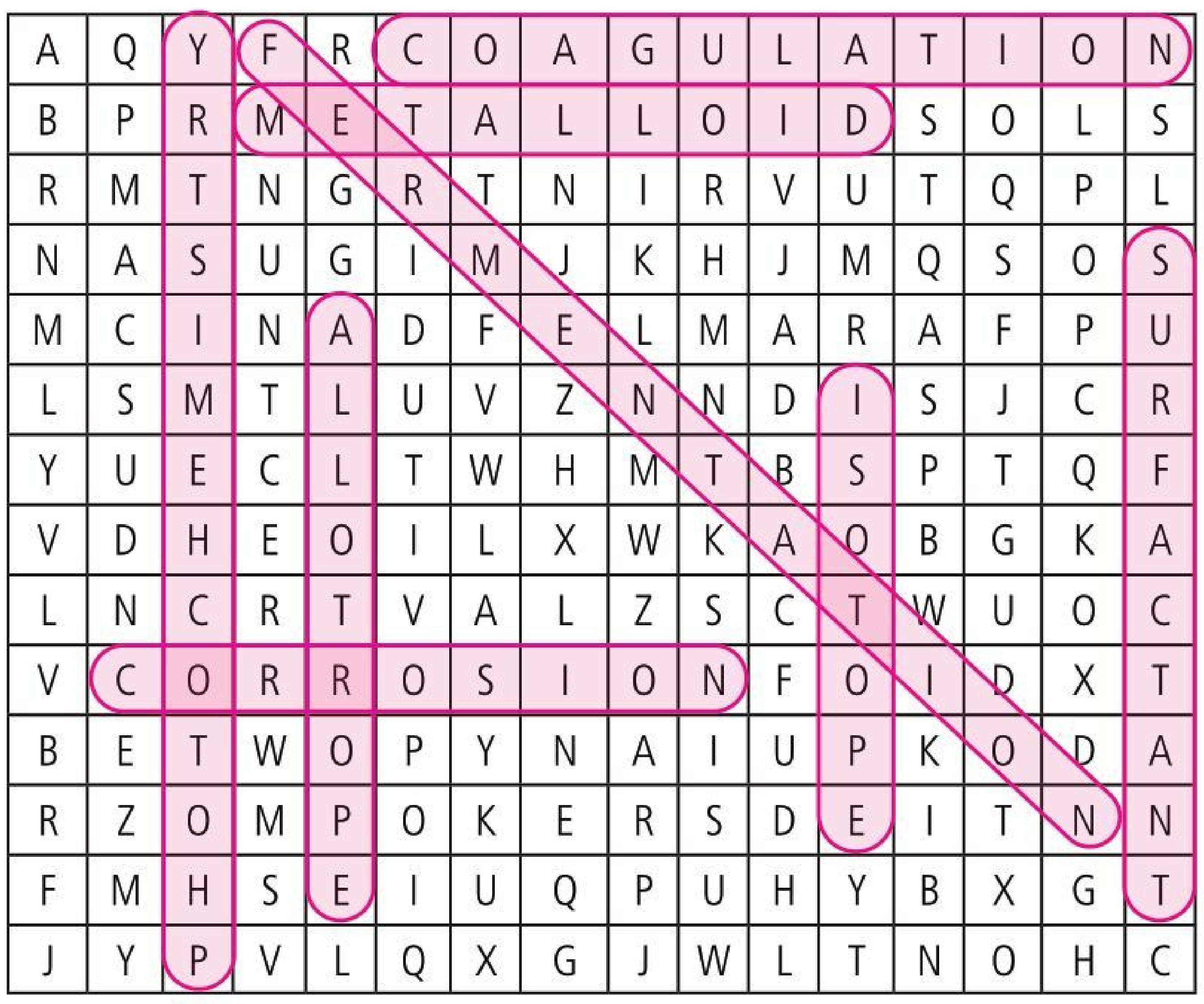
SECTION C

This section contains 5 questions with internal choice in two questions. The following questions are short answer type and carry 3 marks each.

26. Arrange the following in the order of decreasing relative reactivity with an electrophile and explain :
toluene, *p*-nitrotoluene, 1, 4-dinitrobenzene

Winner : Kaushikkumar Kevadiya

SOLUTIONS TO DECEMBER 2022 WORD GRID

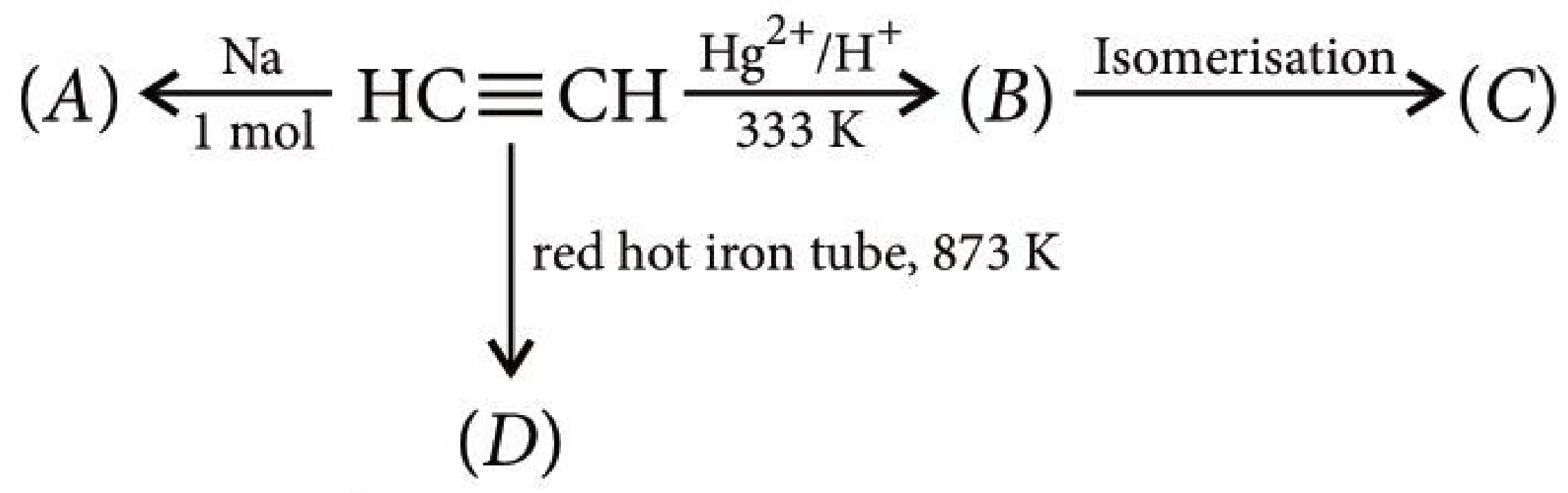


A	Q	Y	F	R	C	O	A	G	U	L	A	T	I	O	N
B	P	R	M	E	T	A	L	L	O	I	D	S	O	L	S
R	M	T	N	G	R	T	N	I	R	V	U	T	Q	P	L
N	A	S	U	G	I	M	J	K	H	J	M	Q	S	O	S
M	C	I	N	A	D	F	E	L	M	A	R	A	F	P	U
L	S	M	T	L	U	V	Z	N	N	D	I	S	J	C	R
Y	U	E	C	L	T	W	H	M	T	B	S	P	T	Q	F
V	D	H	E	O	I	L	X	W	K	A	O	B	G	K	A
L	N	C	R	T	V	A	L	Z	S	C	T	W	U	O	C
V	C	O	R	R	O	S	I	O	N	F	O	I	D	X	T
B	E	T	W	O	P	Y	N	A	I	U	P	K	O	D	A
R	Z	O	M	P	O	K	E	R	S	D	E	I	T	N	N
F	M	H	S	E	I	U	Q	P	U	H	Y	B	X	G	T
J	Y	P	V	L	Q	X	G	J	W	L	T	N	O	H	C

1. Allotrope	5. Coagulation
2. Corrosion	6. Photochemistry
3. Fermentation	7. Surfactant
4. Isotope	8. Metalloid

27. Ethyne reacts with dil. H_2SO_4 in presence of mercury salt to give acetaldehyde but with dil. HCl under similar conditions, it gives vinyl chloride. Explain why?

28. Identify *A*, *B*, *C* and *D*.



29. Convert benzene into :

(a) acetophenone

(b) *m*-chloronitrobenzene

(c) toluene.

OR

(a) Write and explain the necessary conditions for a system to be aromatic.

(b) Out of benzene and toluene, which will undergo nitration easily, and why?

30. Give reasons for **any three** of the following :

(i) Chlorination of methane does not occur in dark.

(ii) Although benzene is highly unsaturated, it does not undergo addition reactions.

(iii) Nitration of benzene is carried out with conc. HNO_3 in presence of conc. H_2SO_4.

(iv) Alkynes give more acidic hydrogen than alkanes and alkenes.

SECTION D

The following questions are case-based questions. Each question has an internal choice and carries 4 (1+1+2) marks each. Read the passage carefully and answer the questions that follow.

31. Arenes are the aromatic hydrocarbons which contain one or more benzene rings. Benzene ring is a six-membered ring containing carbon atoms linked to each other with an alternate single and double bonds. Arenes contain higher proportion of carbon as compared to the aliphatic hydrocarbons and constitute a unique class of unsaturated hydrocarbons. Aromatic hydrocarbons are less reactive than alkenes and alkynes because their π-electrons are involved in delocalisation and not available for addition reactions. But the benzene ring is electron rich so the electrophile can replace H-atom of the benzene ring. Thus aromatic hydrocarbons undergo electrophilic substitution reactions.

Answer the following questions :

(a) Explain why benzene is extraordinarily stable though it contains three double bonds.

(b) Name an *ortho* and *para* directing deactivating group.

(c) –OH group attached to benzene ring is *ortho*, *para*-directing and activating. Explain with the help of resonance structures.

OR

What are *meta* directing groups, give examples?

32. Alkanes are associated through weak van der Waals forces of attraction. Due to this weak intermolecular interaction, they have lower boiling point. Due to non-polar nature, they are insoluble in water. While boiling point increases with increase in molecular mass.

Answer the following questions:

(a) *n*-pentane has greater boiling point than *iso*-pentane.

(b) Amongst the following, which one has the maximum boiling point?
n-pentane, *iso*-pentane, *neo*-pentane

(c) What effect does branching have on the boiling point of an alkane and why?

OR

Explain the solubility of alkanes in water.

SECTION E

The following questions are long answer type and carry 5 marks each. Two questions have an internal choice.

33. (a) An alkyne (*X*) has molecular formula C_5H_8. It reacts neither with sodamide nor with ammoniacal cuprous chloride. Give the name of the compound.

(b) A hydrocarbon (*Y*) decolourises bromine water. On ozonolysis, it gives 3-methyl butanal and formaldehyde. Give the structure of the compound.

MONTHLY TEST DRIVE CLASS XI ANSWER KEY

1.	(c)	**2.**	(c)	**3.**	(a)	**4.**	(a)	**5.**	(c)
6.	(c)	**7.**	(a)	**8.**	(a)	**9.**	(a)	**10.**	(c)
11.	(a)	**12.**	(a)	**13.**	(a)	**14.**	(c)	**15.**	(a)
16.	(d)	**17.**	(b)	**18.**	(c)	**19.**	(a)	**20.**	(b, c)
21.	(a,c)	**22.**	(b,c,d)	**23.**	(b,d)	**24.**	(6)	**25.**	(2)
26.	(9)	**27.**	(d)	**28.**	(b)	**29.**	(b)	**30.**	(d)

(c) A hydrocarbon (*Z*) has molecular formula C_8H_{10}. It does not decolourise bromine water and is oxidised to benzoic acid on heating with $K_2Cr_2O_7$. It can also have three other isomers *A*, *B* and *C*. Write the structures of *Z, A, B* and *C*.

OR

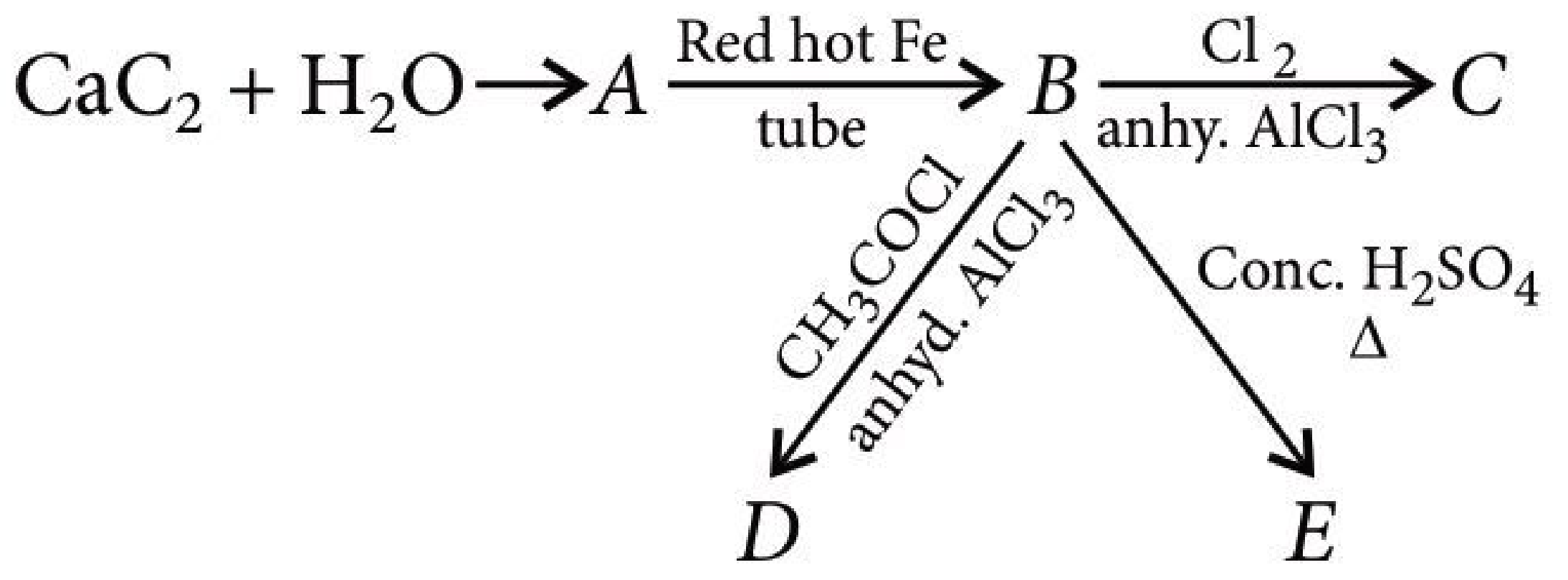
(a) Explain the following reactions :
(i) Ozonolysis (ii) Decarboxylation

(b) What is Saytzeff rule?

(c) Define Wurtz reaction with example.

(d) Write the structure of compound named 2, 3-Dimethylbut-2-ene.

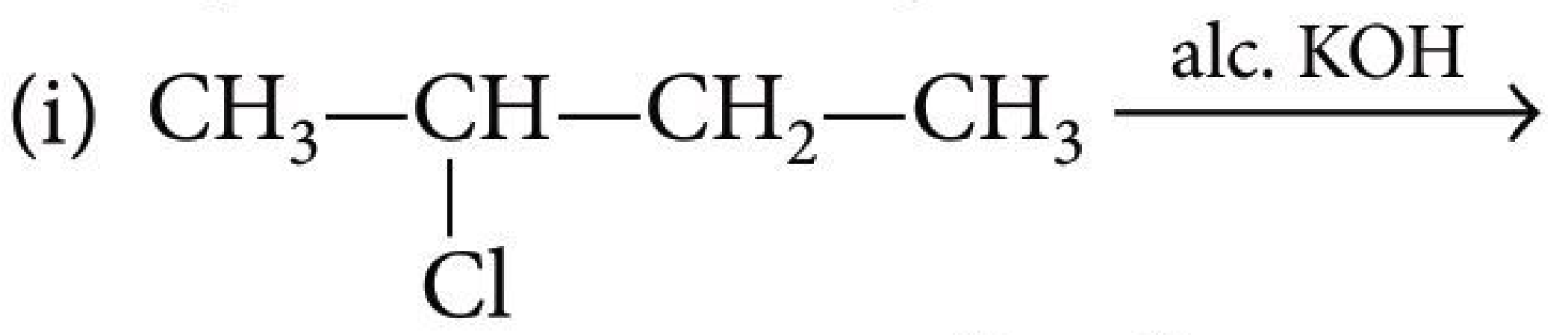
34. Identify *A*, *B*, *C*, *D* and *E* in the following sequence of reactions :



OR

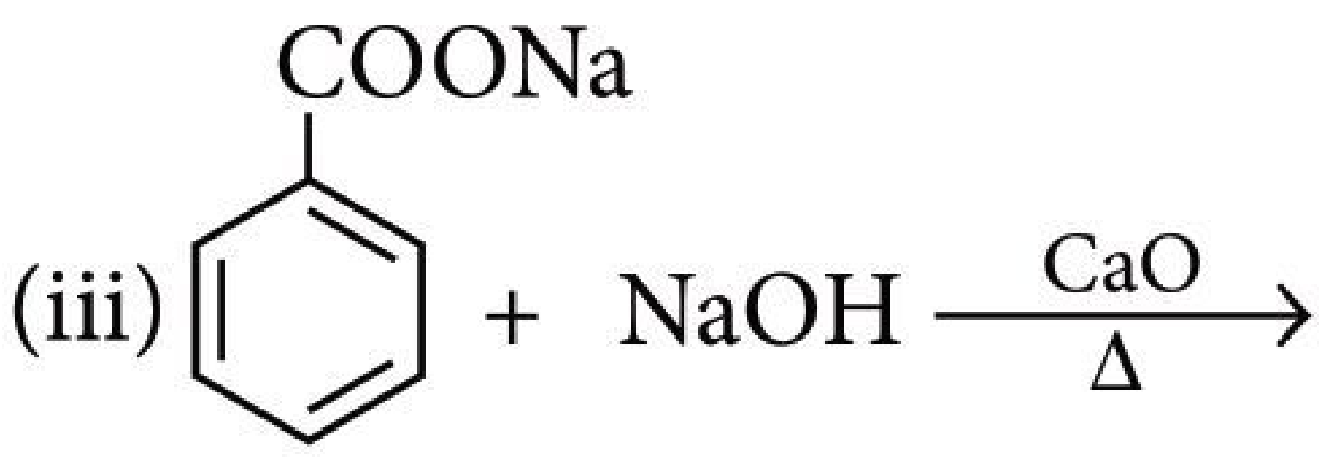
(a) Propanal and pentan-3-one are the ozonolysis products of an alkene. What is the structural formula of the alkene? Write the complete reaction.

(b) Complete the following reactions:

(i) 

$$CH_3-\underset{Cl}{\underset{|}{CH}}-CH_2-CH_3 \xrightarrow{\text{alc. KOH}}$$

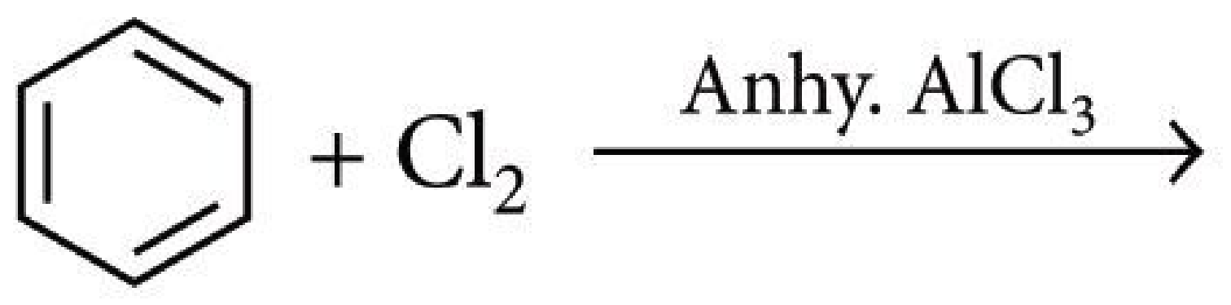
(ii) $CH_3\,CH_2\,Br + Mg \xrightarrow{\text{Dry ether}}$

(iii) 

35. (a) What are nucleophiles? Give examples.

(b) Give chemical equations to explain the following reactions :
(i) Kolbe's electrolysis.
(ii) Friedel-Crafts acylation.

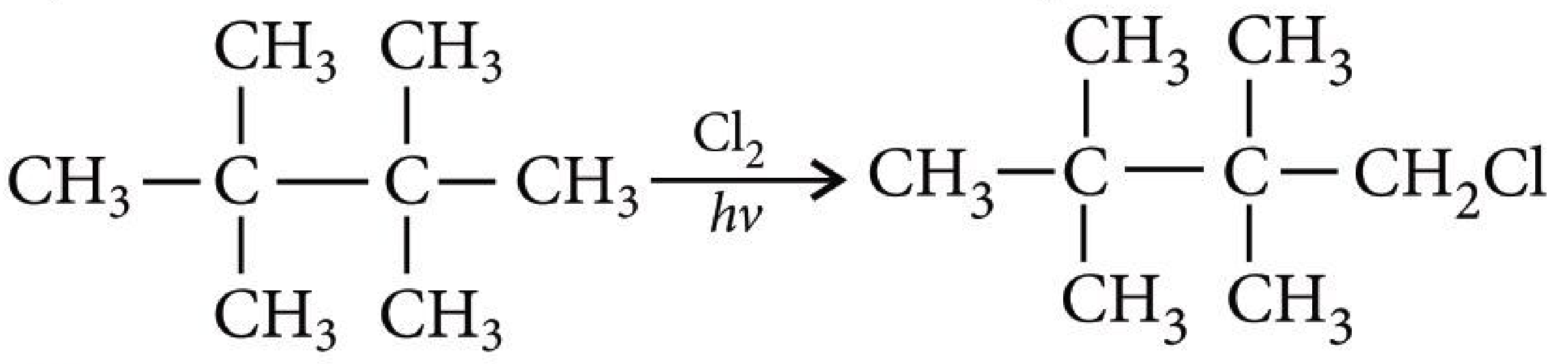
(c) Give mechanism for the following reaction.



SOLUTIONS

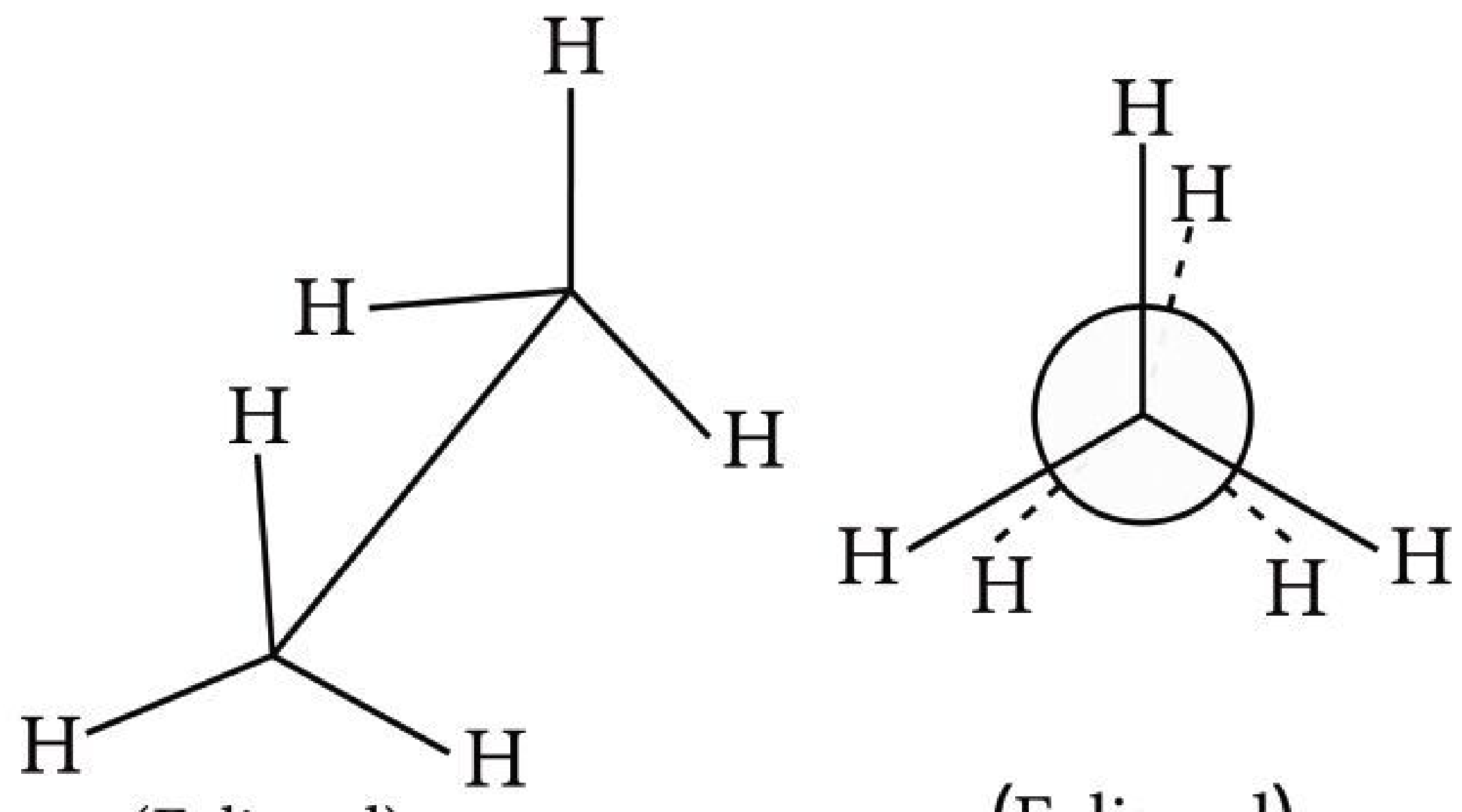
1.	(a)	2.	(b)	3.	(b)	4.	(b)
5.	(b)	6.	(c)	7.	(b)	8.	(d)
9.	(c)	10.	(c)	11.	(c)	12.	(c)
13.	(a)	14.	(c)	15.	(c)	16.	(a)
17.	(c)	18.	(a)				

19. Since, the hydrocarbon (C_8H_{18}) on monochlorination gives a single monochloride, thus, all the 18 H-atoms are equivalent. The only such hydrocarbon is 2, 2, 3, 3-tetramethylbutane, *i.e.*,



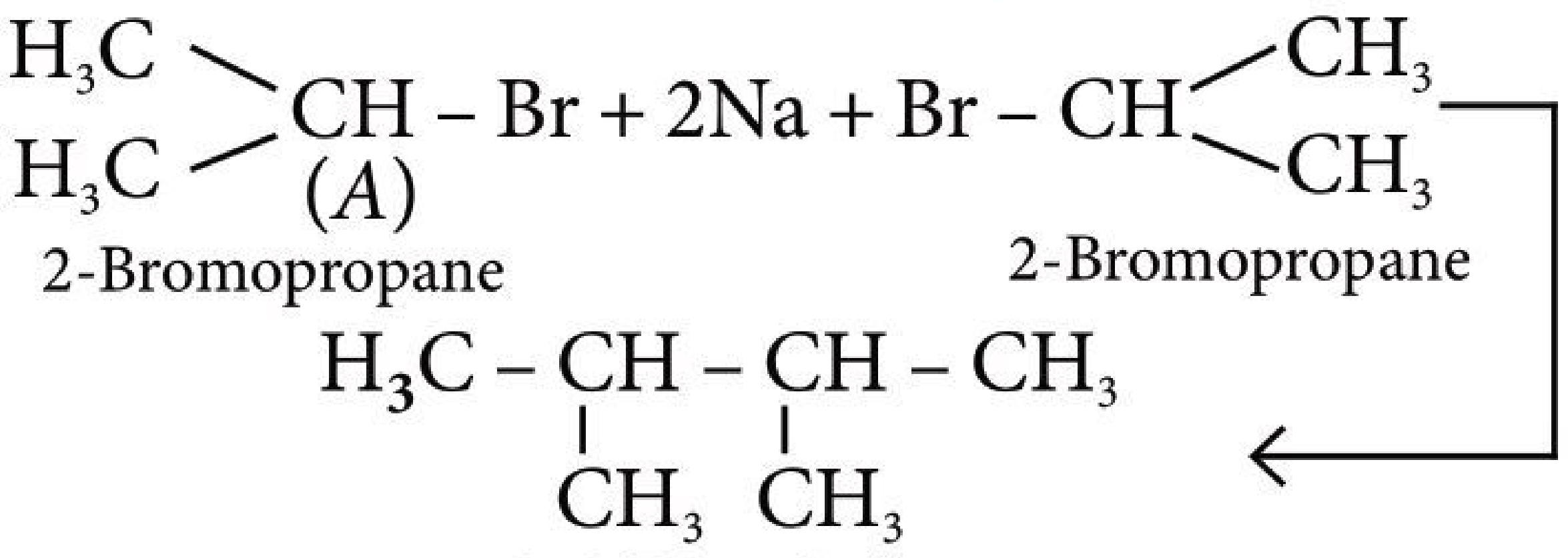
$$CH_3-\underset{CH_3}{\underset{|}{\overset{CH_3}{\overset{|}{C}}}}-\underset{CH_3}{\underset{|}{\overset{CH_3}{\overset{|}{C}}}}-CH_3 \xrightarrow[h\nu]{Cl_2} CH_3-\underset{CH_3}{\underset{|}{\overset{CH_3}{\overset{|}{C}}}}-\underset{CH_3}{\underset{|}{\overset{CH_3}{\overset{|}{C}}}}-CH_2Cl$$

20. Conformations of ethane using sawhorse and newman projections are respectively:



(Eclipsed) (Eclipsed)

OR



$$\begin{matrix}H_3C\\H_3C\end{matrix}\!\!>\underset{(A)}{CH}-Br + 2Na + Br-CH<\!\!\begin{matrix}CH_3\\CH_3\end{matrix} \longrightarrow H_3C-\underset{CH_3}{\underset{|}{CH}}-\underset{CH_3}{\underset{|}{CH}}-CH_3$$

2-Bromopropane 2-Bromopropane

2, 3-Dimethylbutane

21. Boiling point decreases with increase in branching. Therefore, increasing order of boiling point :
2, 2-dimethylpropane < 2-methylbutane < pentane

TRIO

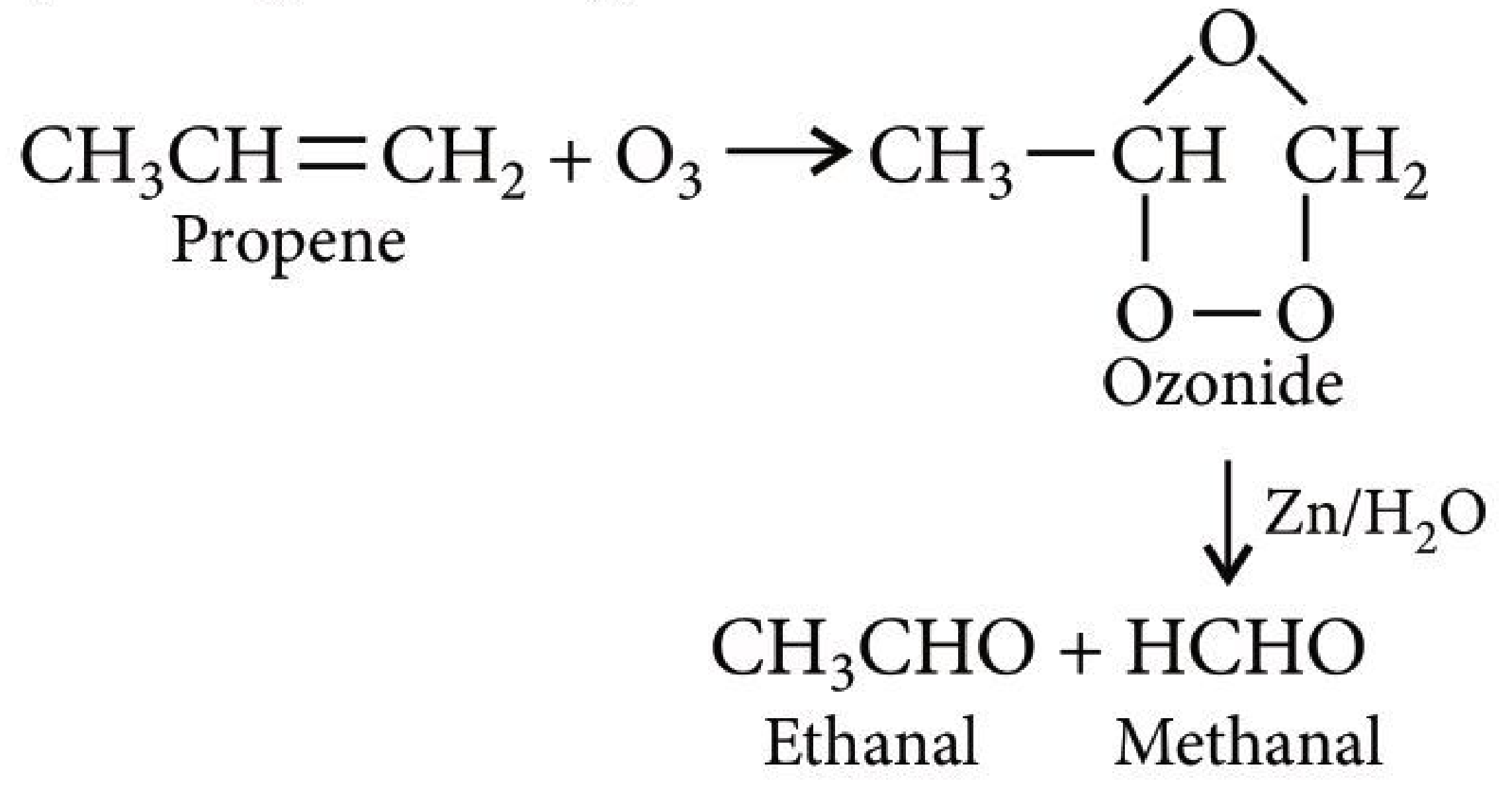
The same THREE LETTERS will complete these five words.

Can you find the three-letter sequence?

QU — — — UM
T— — — ALUM
— — — ISEPTIC
L — — — HANUM
CONST— — — S

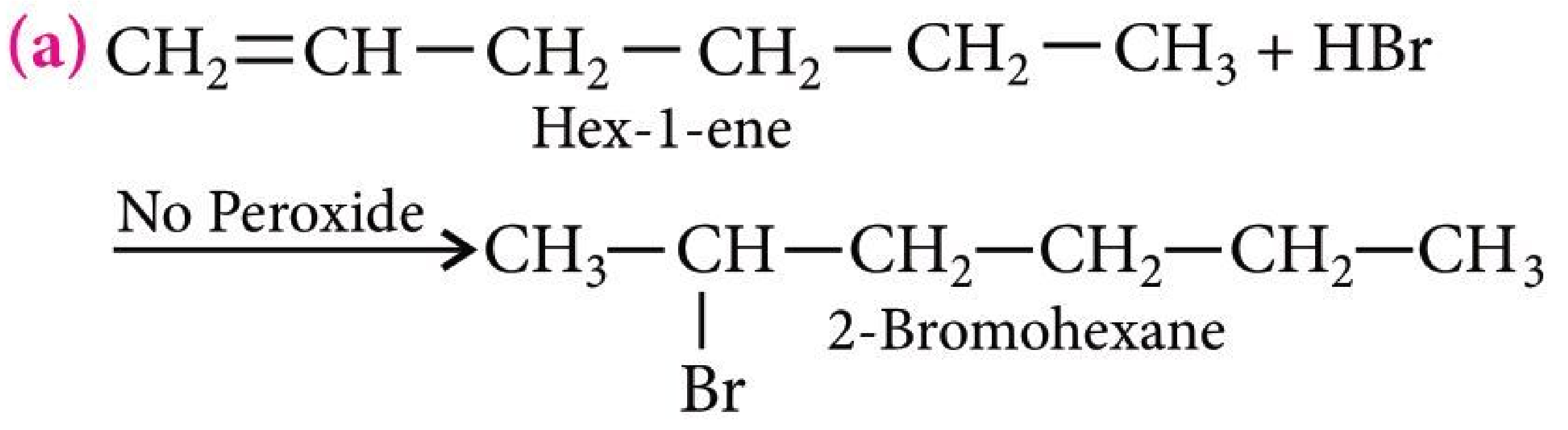
Readers can send their responses at editor@mtg.in or post us with complete address by 10th of every month.
Winners' names will be published in next issue.

22. Alkenes react with O_3 to give ozonide which on reduction with Zn / H_2O gives smaller molecules of carbonyl compound. *e.g.,*



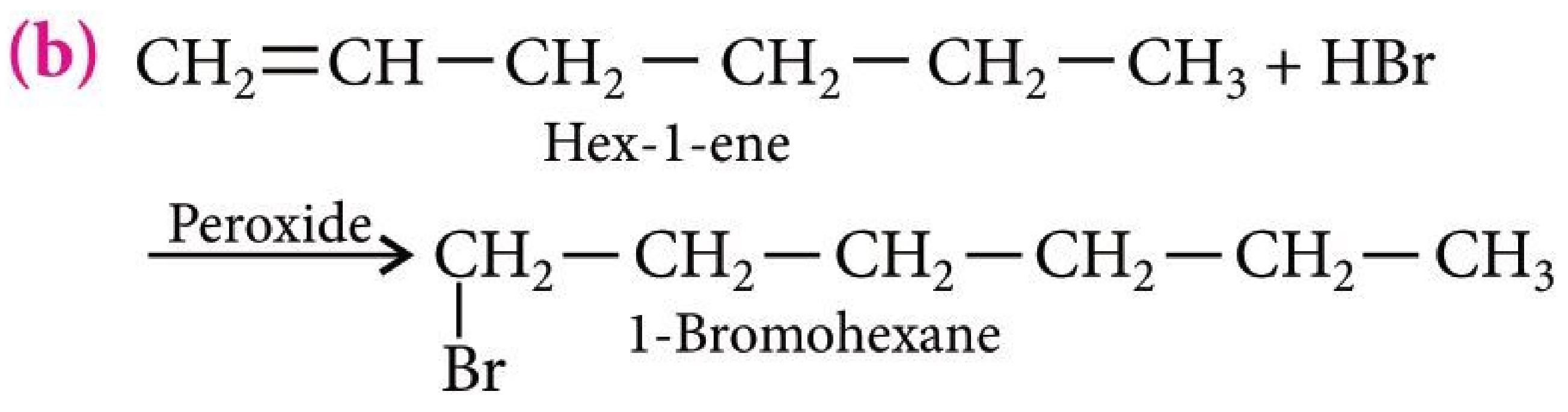
$CH_3CH{=}CH_2 + O_3 \longrightarrow$ Ozonide $\xrightarrow{Zn/H_2O}$ $CH_3CHO + HCHO$
Propene
Ozonide
Zn/H_2O
Ethanal
Methanal

OR



$$\underset{\text{Hex-1-ene}}{CH_2{=}CH{-}CH_2{-}CH_2{-}CH_2{-}CH_3} + HBr \xrightarrow{\text{No Peroxide}} \underset{\text{2-Bromohexane}}{CH_3{-}\underset{|\atop Br}{CH}{-}CH_2{-}CH_2{-}CH_2{-}CH_3}$$

(a)



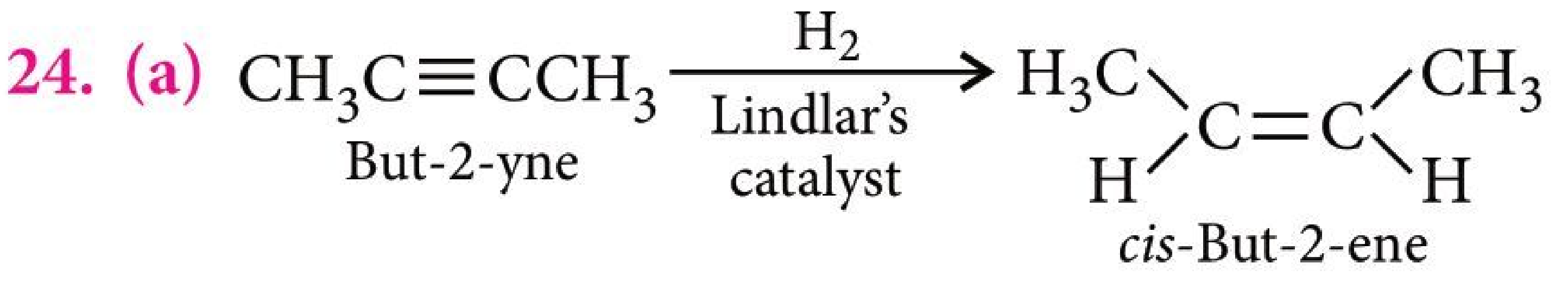
$$\underset{\text{Hex-1-ene}}{CH_2{=}CH{-}CH_2{-}CH_2{-}CH_2{-}CH_3} + HBr \xrightarrow{\text{Peroxide}} \underset{\text{1-Bromohexane}}{\underset{|\atop Br}{CH_2}{-}CH_2{-}CH_2{-}CH_2{-}CH_2{-}CH_3}$$

(b)

23. Acidic dehydration : Alcohols on heating with conc. H_2SO_4 form alkenes with elimination of one water molecule. Since, a water molecule is lost in the presence of acid, the reaction is called acidic dehydration of alcohols.

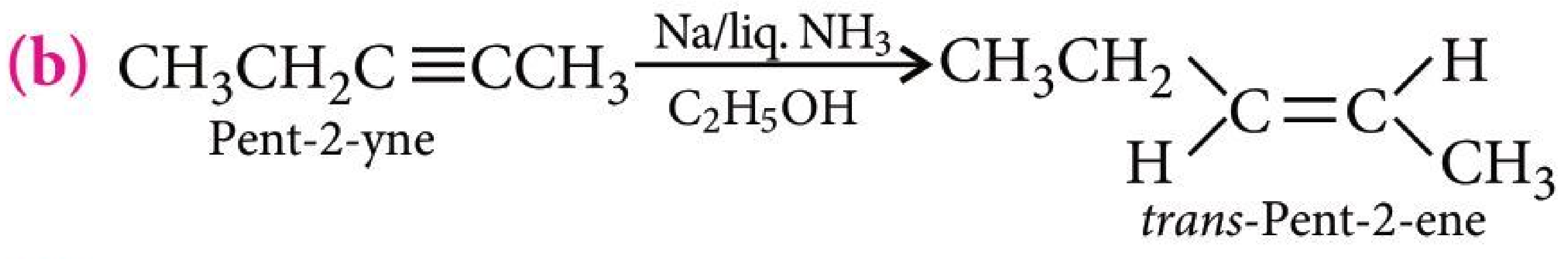
$$CH_3{-}CH_2OH \xrightarrow{\text{conc. } H_2SO_4} CH_2{=}CH_2 + H_2O$$

24. (a)



$CH_3C{\equiv}CCH_3$
But-2-yne
H_2
Lindlar's catalyst
H_3C
CH_3
H
H
cis-But-2-ene

(b)



$CH_3CH_2C{\equiv}CCH_3$
Pent-2-yne
Na/liq. NH_3
C_2H_5OH
CH_3CH_2
H
H
CH_3
trans-Pent-2-ene

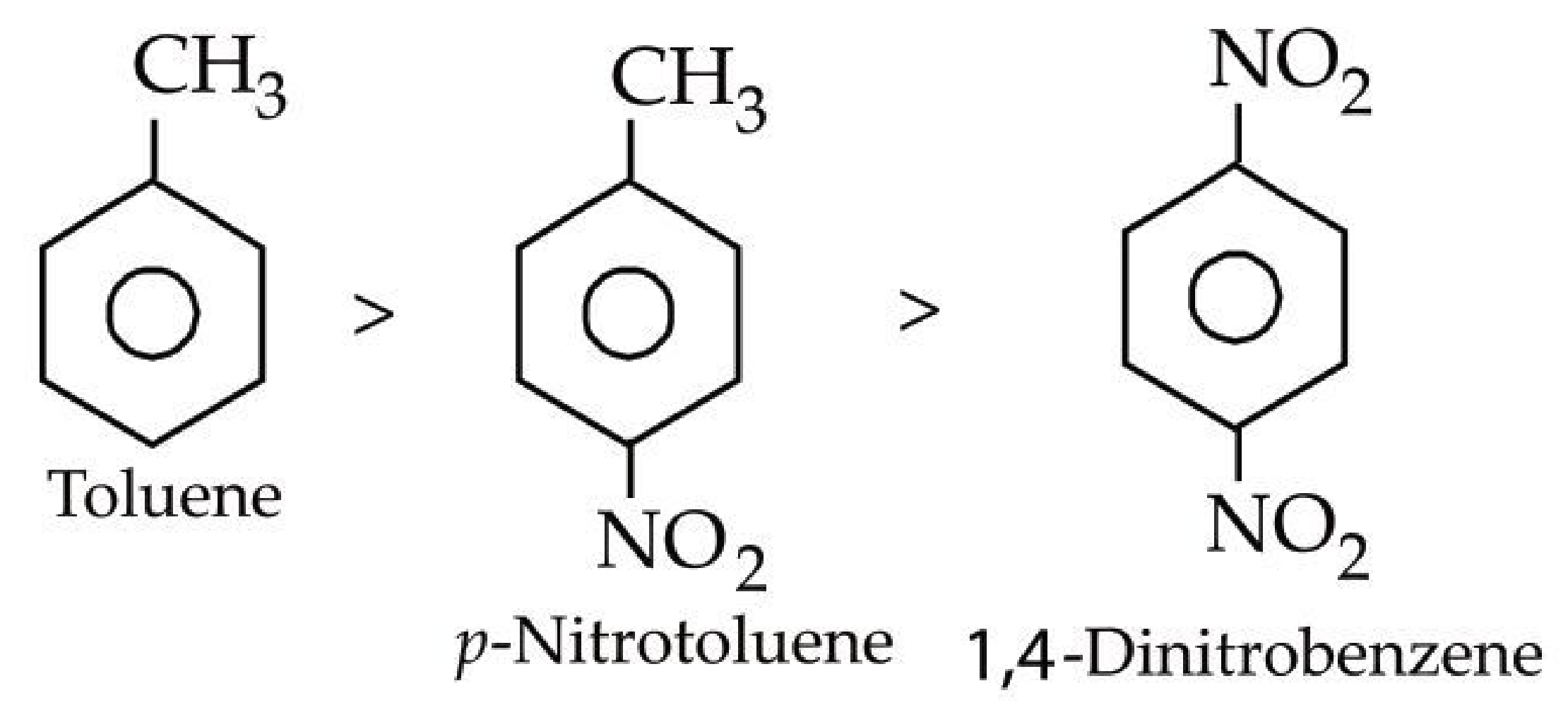
25. Ethyne reacts with sodium to form sodium acetylide and hydrogen gas. However, this reaction is not given by ethene.

$$\underset{\text{Ethyne}}{HC{\equiv}CH} + Na \longrightarrow HC{\equiv}C^-Na^+ + \frac{1}{2}H_2$$

$$HC{\equiv}C^-Na^+ + Na \longrightarrow \underset{\text{Disodium ethynide}}{Na^+C^-{\equiv}C^-Na^+} + \frac{1}{2}H_2$$

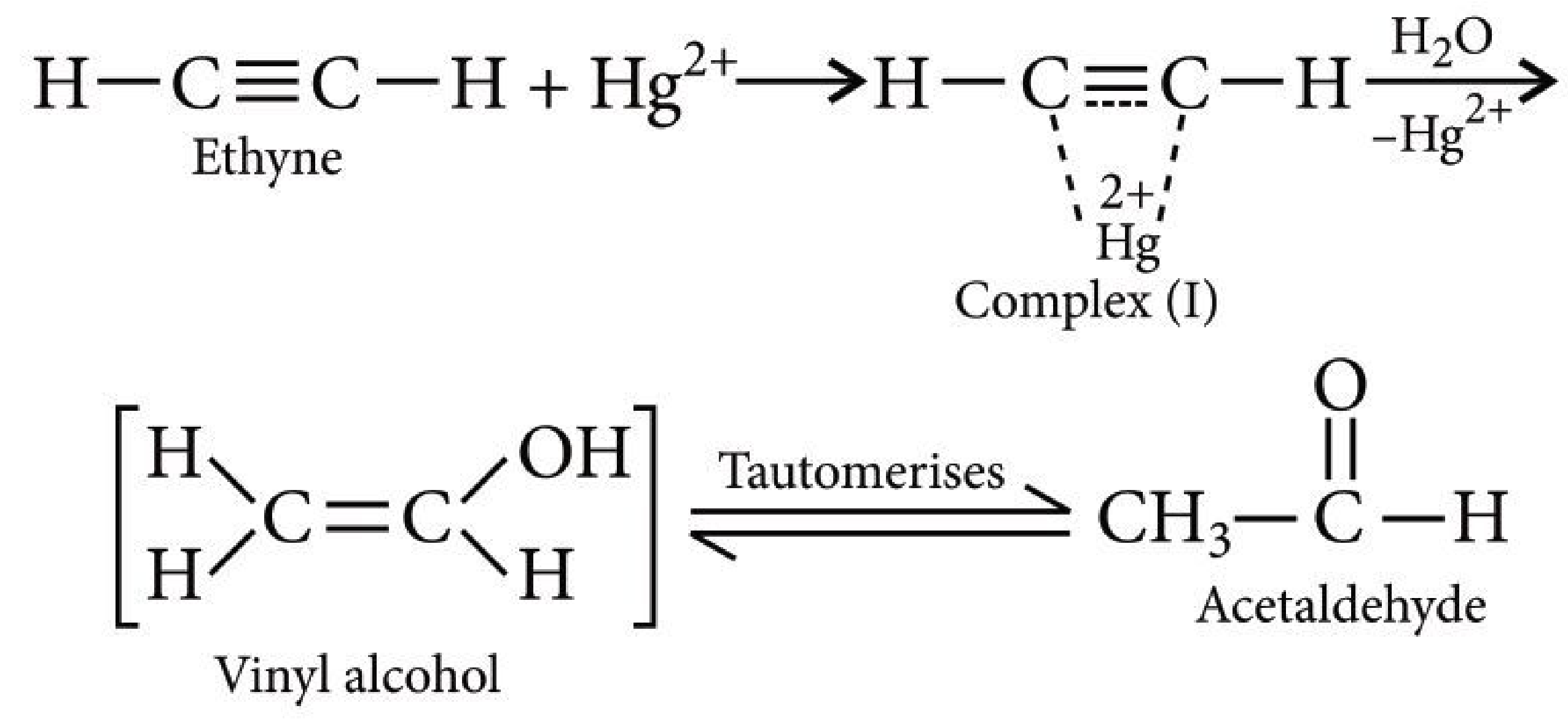
$$\underset{\text{Ethene}}{CH_2{=}CH_2} + Na \longrightarrow \text{No reaction}$$

26. Any substituted benzenoid compound is said to be more reactive towards an electrophile if the substituent on benzene ring increases electron density on it by electron donation. Since, $-CH_3$ group is electron releasing group and activates the ring towards electrophile whereas, $-NO_2$ group is electron withdrawing group and deactivates the ring towards electrophile. Therefore, order is :



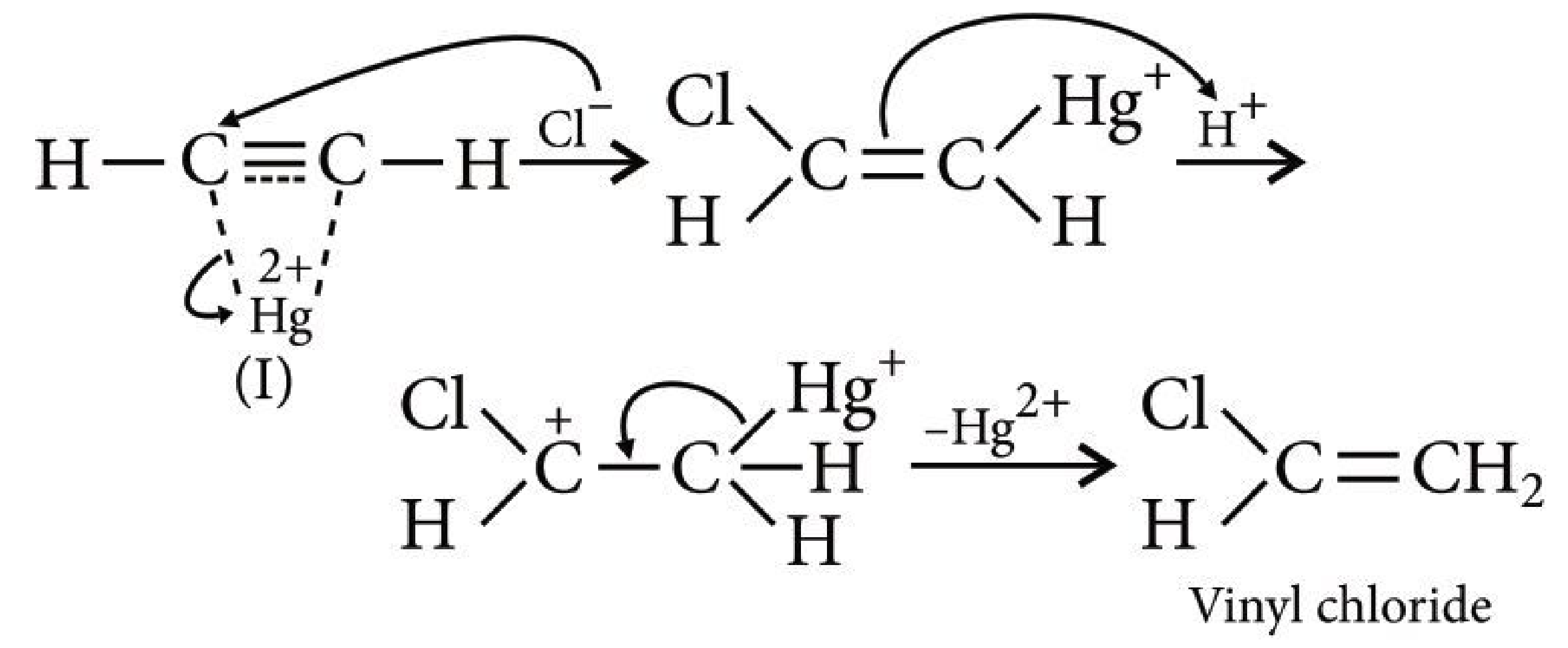
CH_3
>
CH_3
>
NO_2
Toluene
NO_2
p-Nitrotoluene
NO_2
1,4-Dinitrobenzene

27. Mercuric ion forms a complex (I) with acetylene. Since, H_2O is more nucleophilic than SO_4^{2-} ion, it attacks the complex (I) to form first vinyl alcohol which further tautomerises to give acetaldehyde.



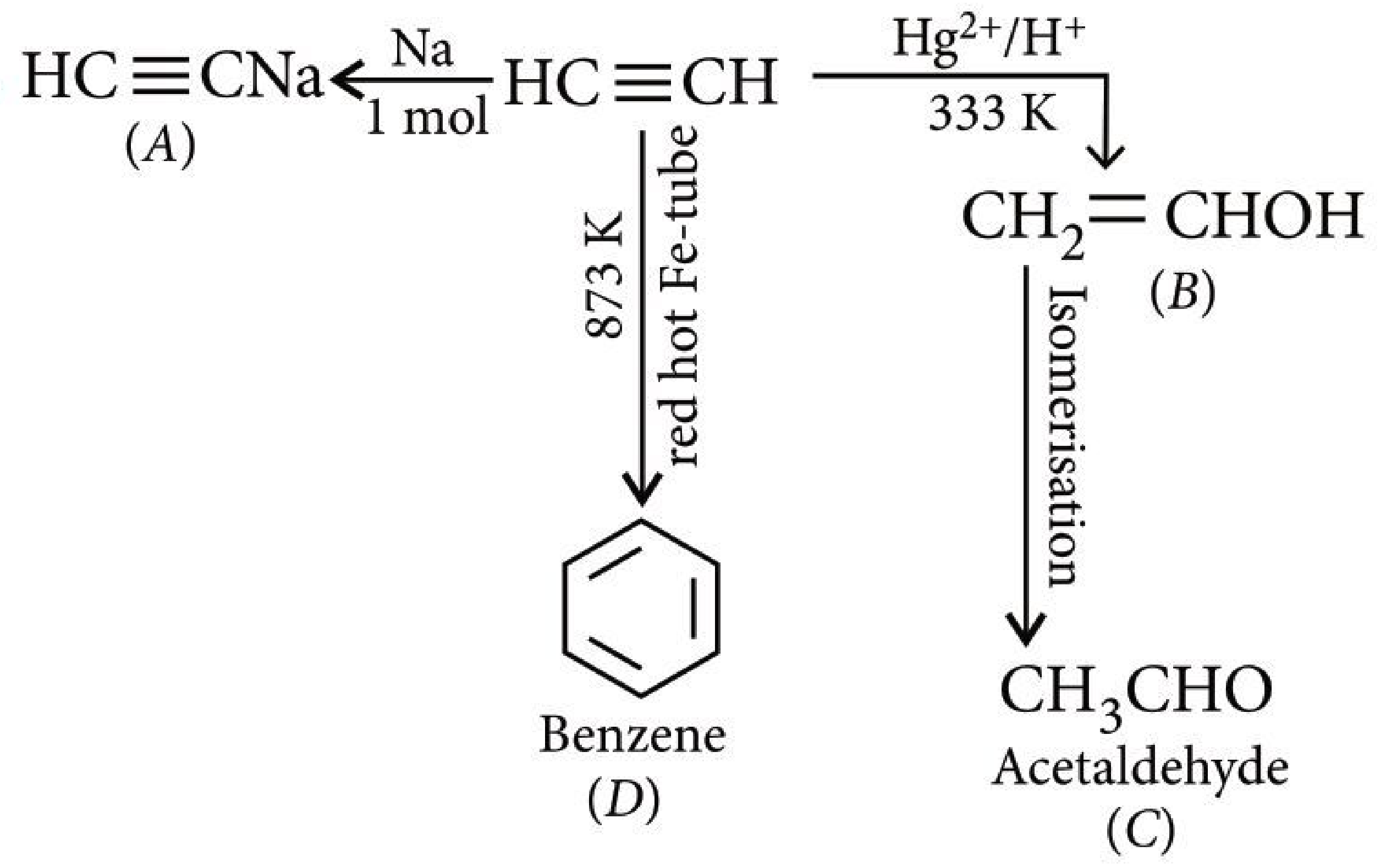
$H{-}C{\equiv}C{-}H + Hg^{2+}$
Ethyne
Hg^{2+}
Complex (I)
H_2O
$-Hg^{2+}$
Vinyl alcohol
Tautomerises
$CH_3{-}\overset{O}{\overset{||}{C}}{-}H$
Acetaldehyde

In case of dil. HCl, Cl^- ion is more nucleophilic than H_2O, it reacts with complex (I) to form vinyl chloride.



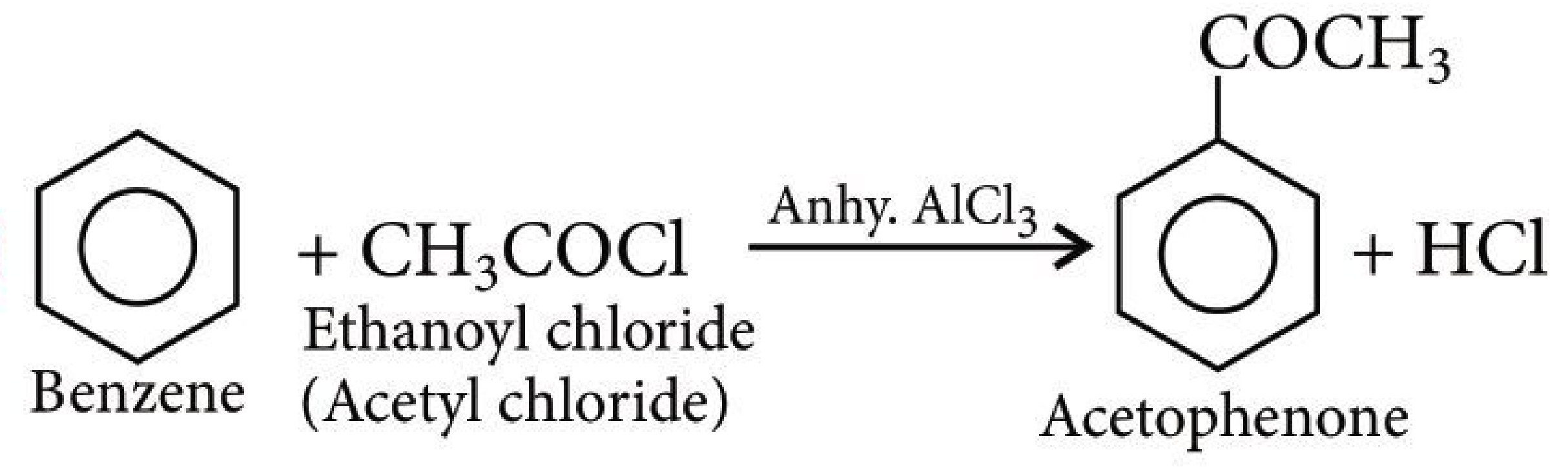
Cl^-
Hg^+
H^+
(I)
$-Hg^{2+}$
Vinyl chloride

28.



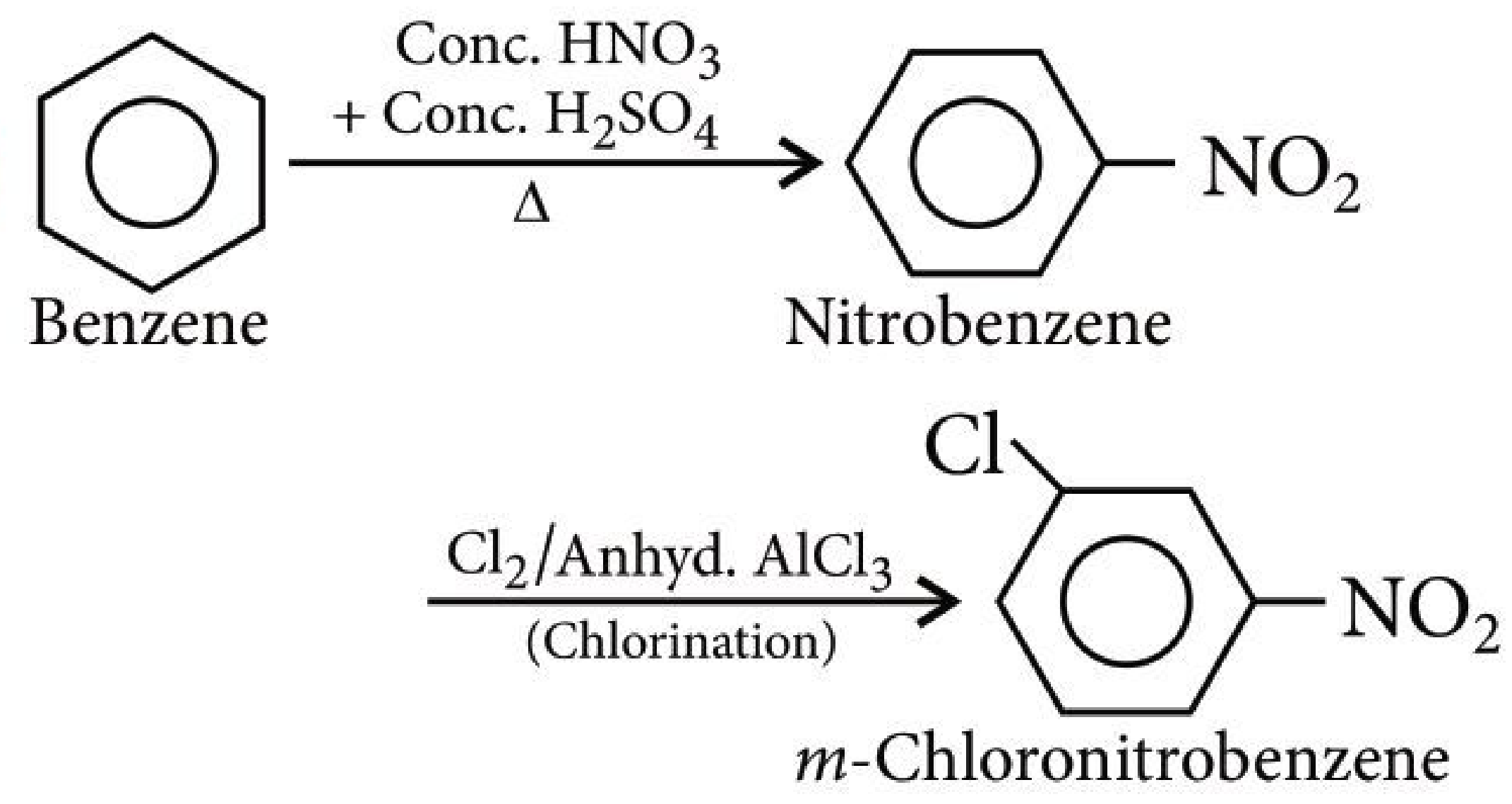
$HC{\equiv}CNa$
(*A*)
Na
1 mol
$HC{\equiv}CH$
Hg^{2+}/H^+
333 K
$CH_2{=}CHOH$
(*B*)
873 K
red hot Fe-tube
Isomerisation
Benzene
(*D*)
CH_3CHO
Acetaldehyde
(*C*)

29. (a)

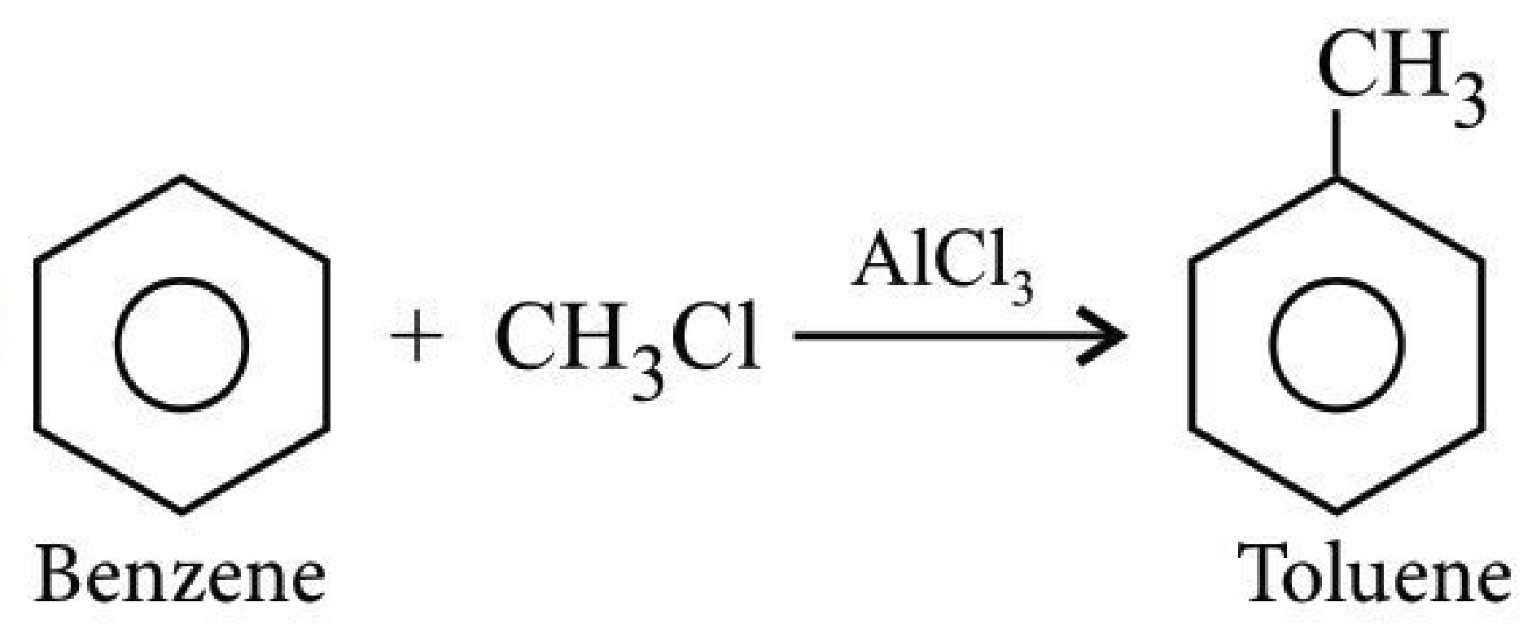


Benzene
+ CH_3COCl
Ethanoyl chloride
(Acetyl chloride)
Anhy. $AlCl_3$
$COCH_3$
+ HCl
Acetophenone

(b)



(c)



OR

(a) The necessary conditions for any system to be aromatic are :

(i) The molecule should be planar.

(ii) It should be cyclic with alternate single and double bonds and the cyclic π cloud should surround all the carbon atoms of the ring.

(iii) It should contain $(4n + 2)\pi$ electrons where $n = 0, 1, 2, 3, \ldots$ etc.

This rule is called Huckel's rule of aromaticity.

(b) Toluene undergoes nitration easily because $—CH_3$ group is electron releasing group, it increases electron density on benzene ring.

30. (i) Chlorination of methane is free radical substitution.To get chlorine free radical energy is required which is provided by sunlight to initiate the reaction.

$$Cl_2 \xrightarrow{h\upsilon} \dot{Cl} + \dot{Cl}$$

(ii) π-electrons of benzene ring are delocalised throughout the molecule. This makes the molecule very stable. The stability resists breaking of double bonds for addition.

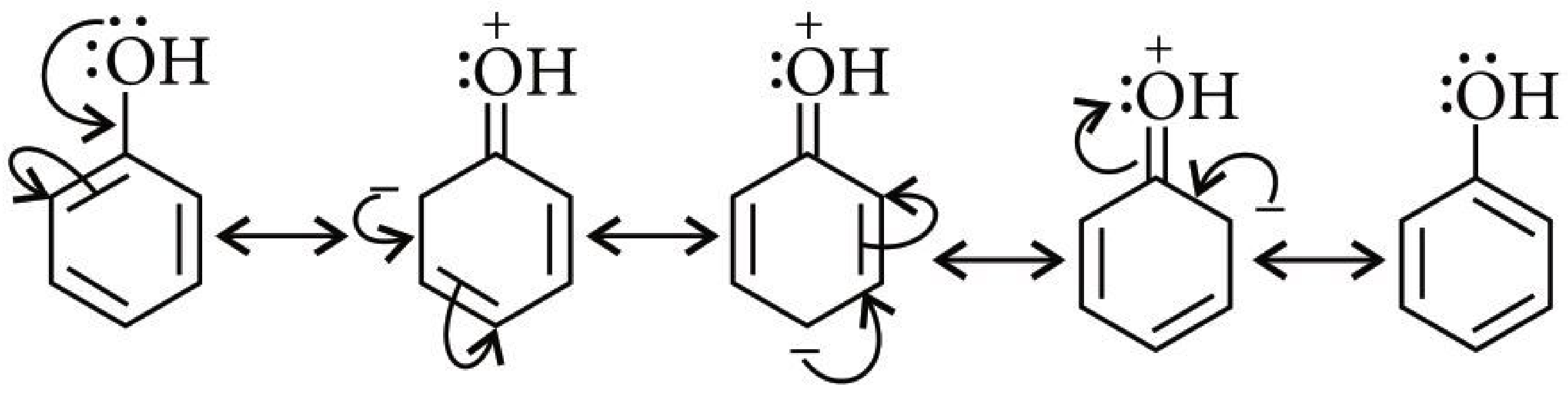
(iii) Electrophile NO_2^+ is generated by the help of H_2SO_4. In absence of H_2SO_4 a nucleophile NO_3^- will be formed which will not be helpful in electrophilic substitution.

(iv) Due to the maximum percentage of *s*-character (50%), the *sp* hybridised orbitals of carbon atoms in ethyne molecules have highest electronegativity, thus in ethyne, hydrogen atoms can be liberated as protons most easily.

31. (a) Benzene is extraordinarily stable though it contains three double bonds as these bonds are in conjugation and resonance stabilized.

(b) Chloro (–Cl) group.

(c) —OH group attached to benzene ring releases electrons and activates the benzene ring, directing the incoming groups to *ortho* and *para* positions.



OR

The groups which direct the incoming group to *meta*-position are called *meta*-directing groups. *e.g.*, $–NO_2$, –CN, –CHO, –CO*R*, –COOH, –COO*R*, $–SO_3H$, etc.

32. (a) *n*-Pentane has higher surface area than *iso* pentane. Hence, the magnitude of van der Waals force is higher in *n*-pentane. Therefore, it has higher boiling point.

(b) *n*-Pentane.

(c) As the branching in an alkane increases, the shape of the molecule approaches a sphere and size of the branched chain alkane becomes less than that of its straight chain counterpart.

The reduced surface area results in decreased van der Waals interaction and finally leads to lower boiling point as compared to straight chain alkanes of comparable molar mass.

OR

Solubility of alkanes increases with increase in molecular mass and decreases as the branching increases due to the decrease in surface area which decreases the van der Waals force of attraction.

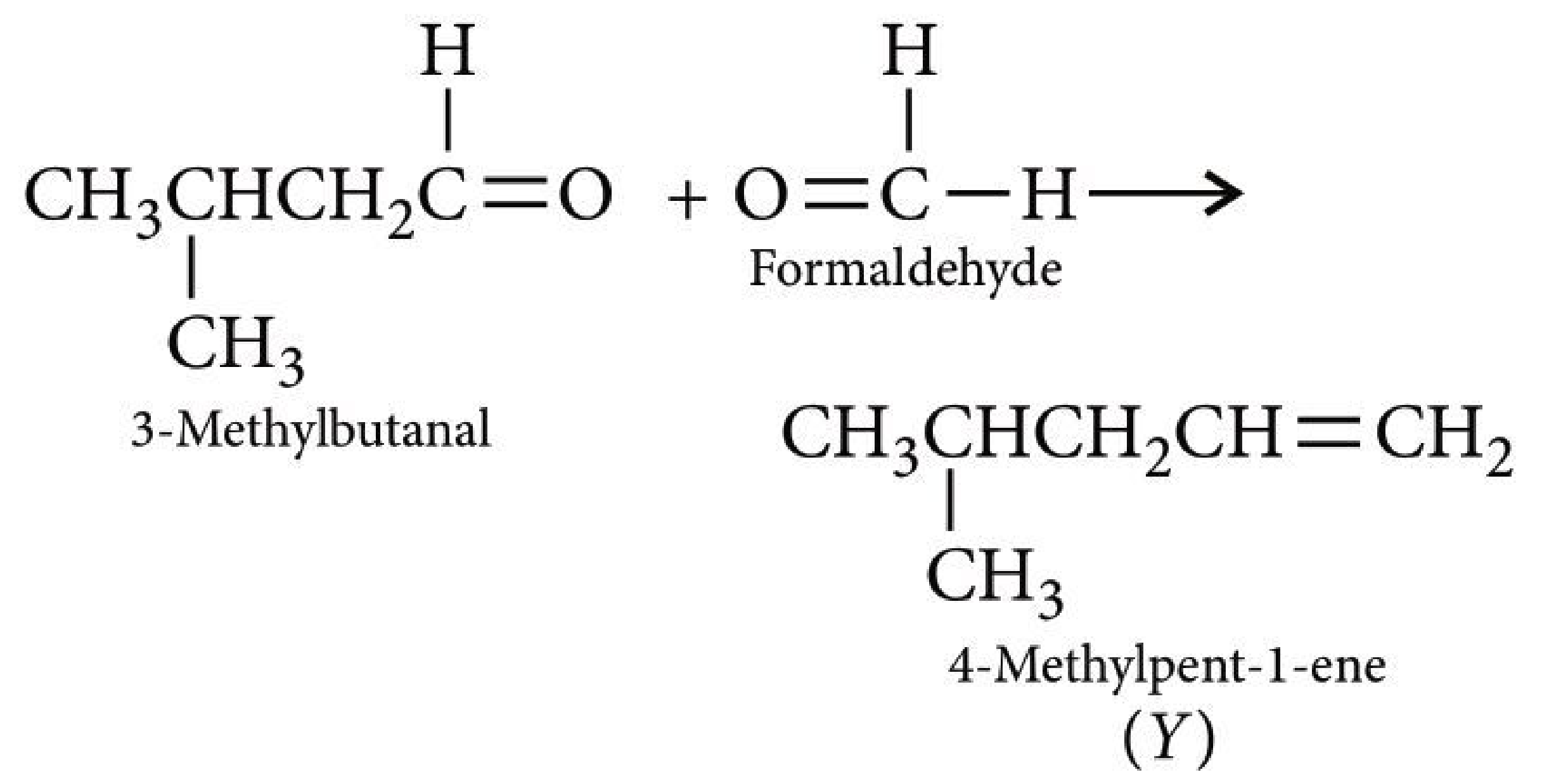
33. (a) Alkyne *X* is Pent-2-yne. Since it does not react with sodamide or ammoniacal cuprous chloride, the triple bond cannot be terminal.

∴ X is $CH_3CH_2C \equiv CCH_3$.

(b) Hydrocarbon '*Y*' is alkene because it decolourises bromine water. From the products of ozonolysis, the structure of alkene can be predicted.

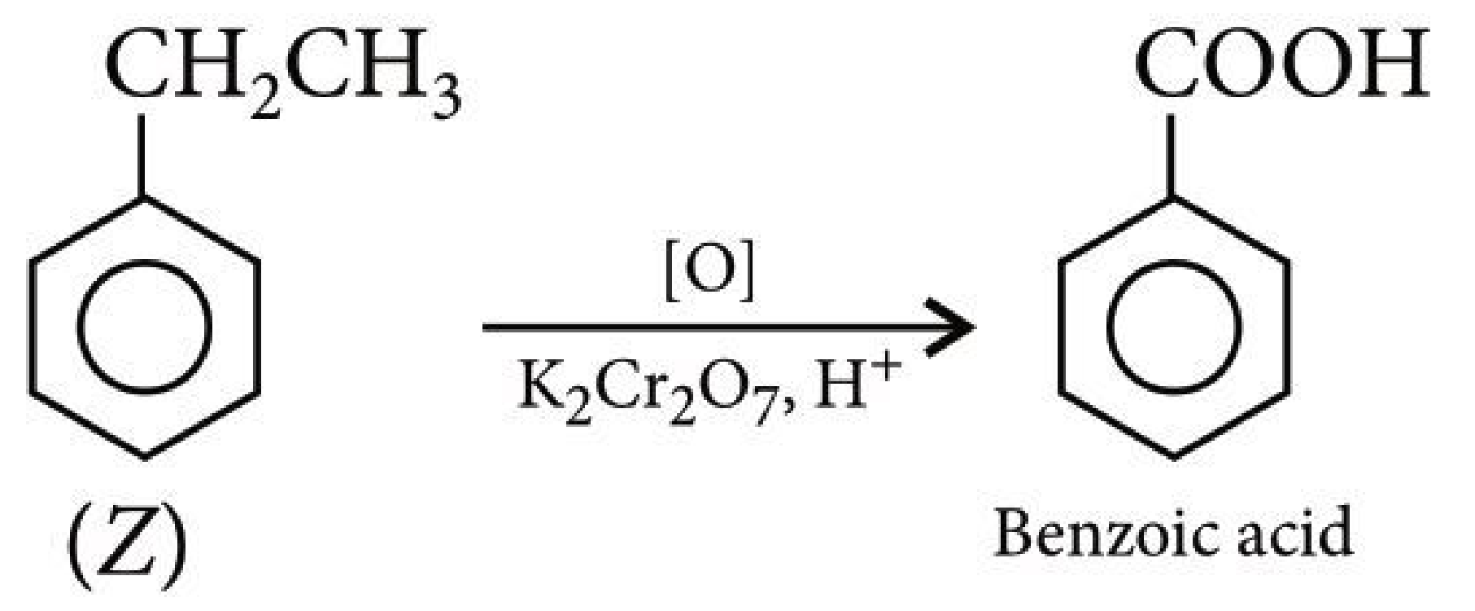
Recipe for Success

"It's hard to beat a person who never gives up."

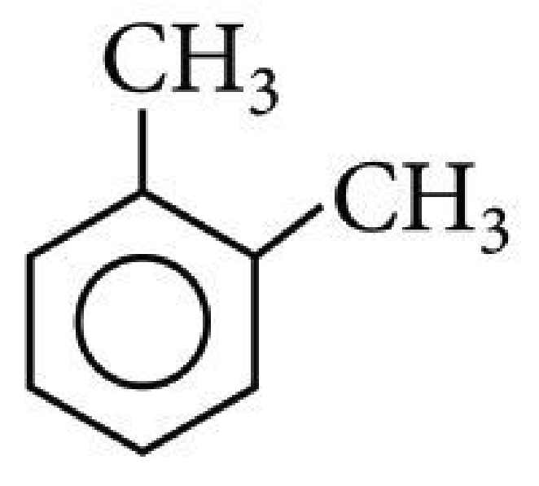

3-Methylbutanal
Formaldehyde
4-Methylpent-1-ene
(Y)

$$CH_3CH(CH_3)CH_2CHO + HCHO \longrightarrow CH_3CH(CH_3)CH_2CH{=}CH_2$$

(c) Since, it does not decolourise bromine water, it is arene. Thus,

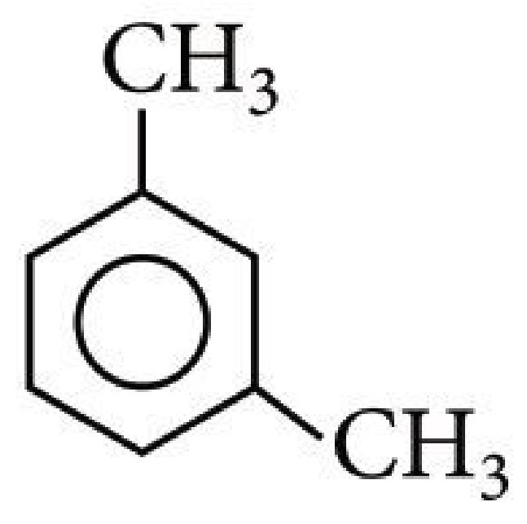

CH_2CH_3
[O]
$K_2Cr_2O_7, H^+$
COOH
(Z)
Benzoic acid

The other three isomers are :



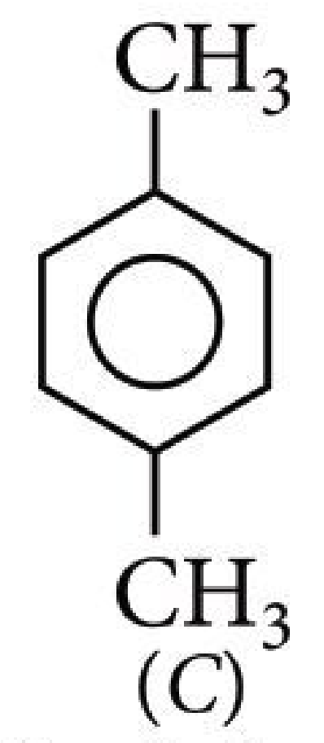
(A)

1, 2-Dimethylbenzene (o-Xylene)



(B)

1, 3-Dimethylbenzene (m-Xylene)

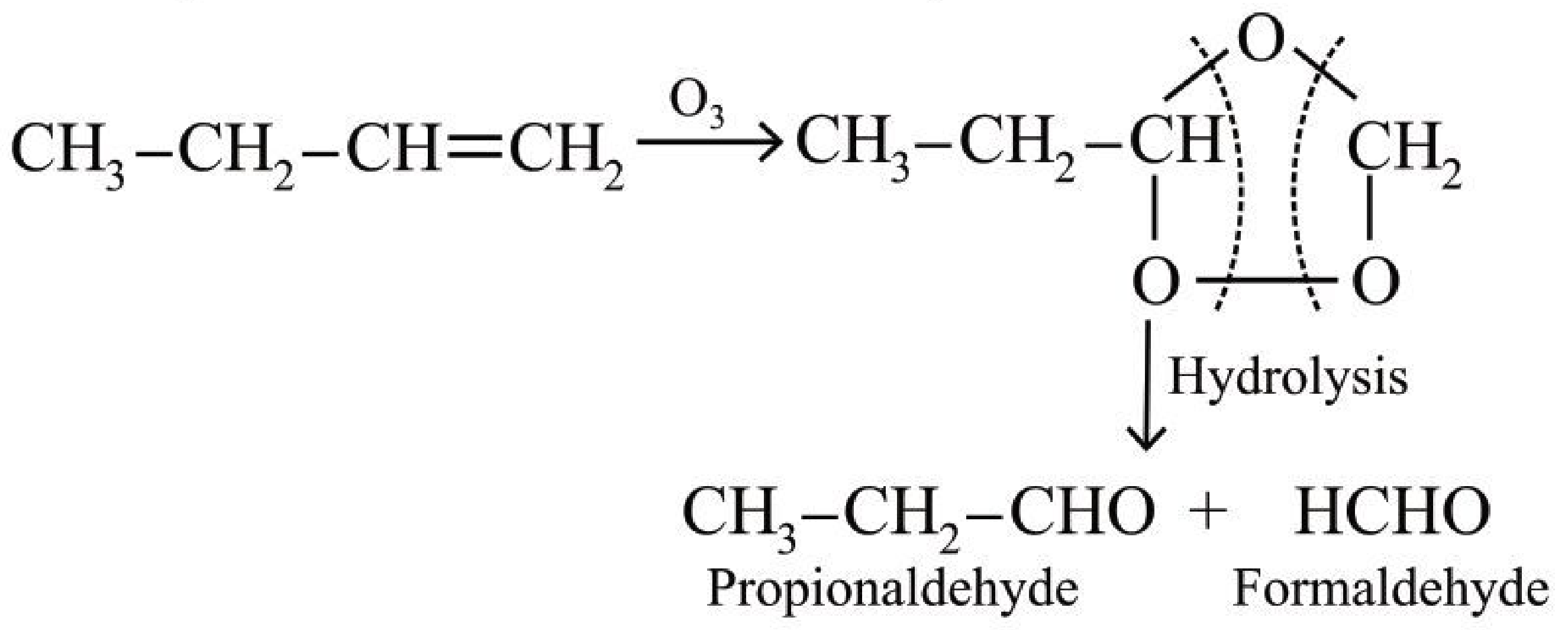


(C)

1, 4-Dimethylbenzene (p-Xylene)

OR

(a) (i) Ozonolysis : Alkenes or alkynes add ozone to form ozonide which on hydrolysis with Zn gives aldehyde or ketone or carboxylic acid.


$CH_3-CH_2-CH=CH_2$
O_3
Hydrolysis
CH_3-CH_2-CHO + HCHO
Propionaldehyde
Formaldehyde

(ii) Decarboxylation : Sodium salts of carboxylic acids on heating with soda lime (mixture of sodium hydroxide and calcium oxide) give alkanes containing one carbon atom less than the carboxylic acid. This process of elimination of carbon dioxide from a carboxylic acid is known as decarboxylation.

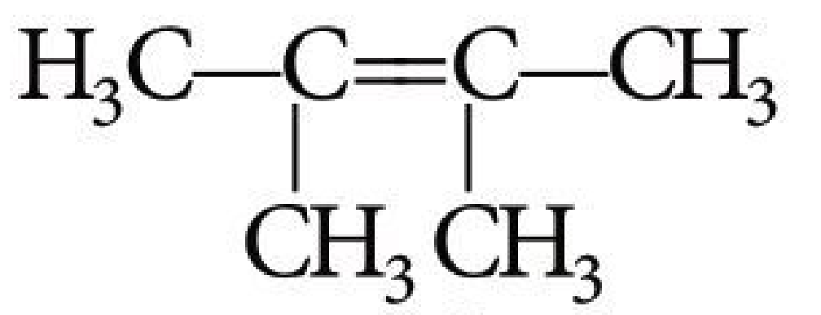
$$RCOONa + NaOH \xrightarrow{CaO,\ 630\ K} R-H + Na_2CO_3$$

(b) Saytzeff rule : If a single starting compound can yield two or more isomers then more substituted alkene is formed in greater amount.

(c) Wurtz reaction : When two moles of alkyl halide react with Na metal in presence of dry ether, alkane with twice the number of carbon atoms as present in the alkyl halide is formed.

$$2CH_3Cl + 2\,Na \xrightarrow[\text{Ether}]{\text{Dry}} CH_3-CH_3 + 2\,NaCl$$

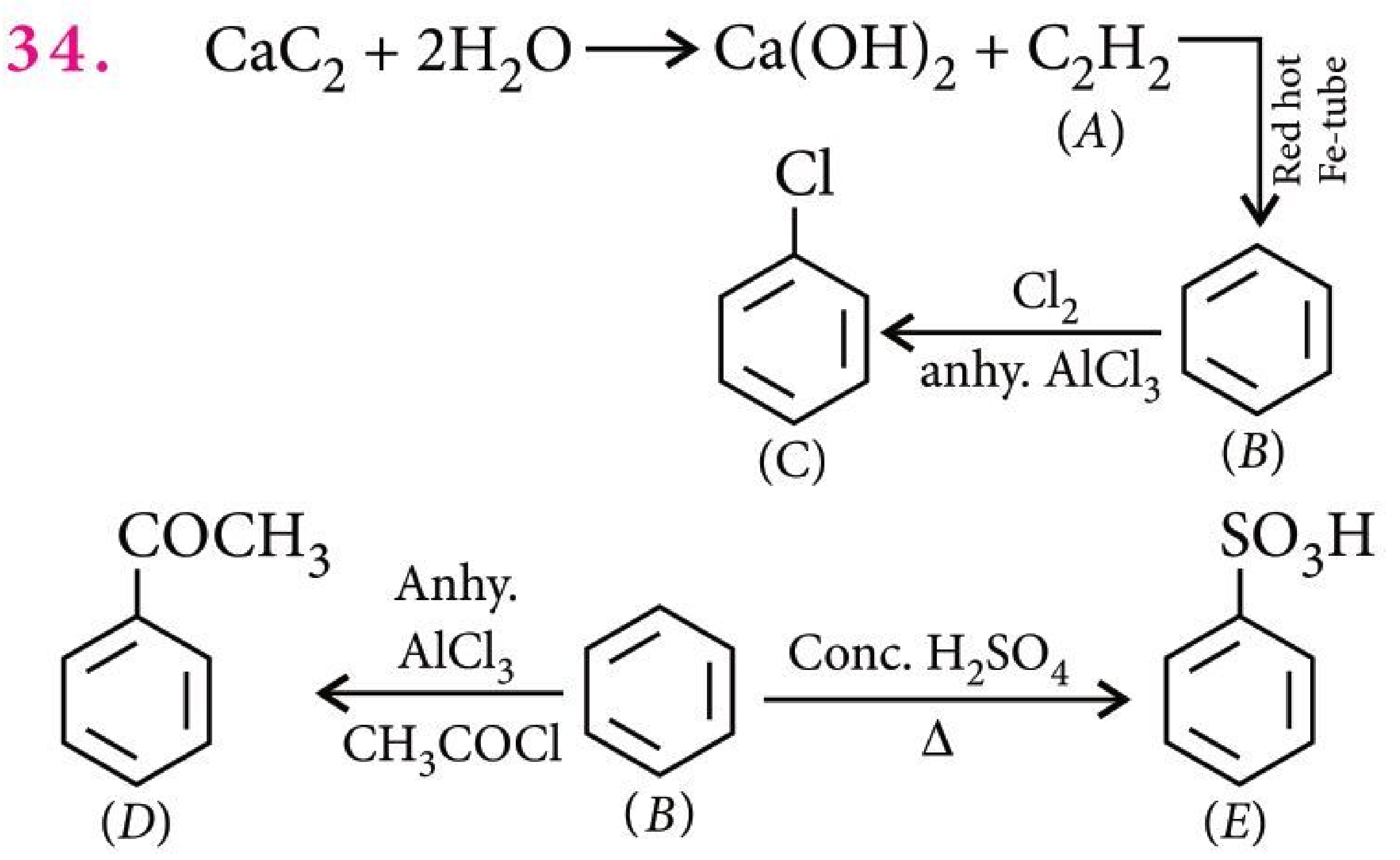
(d)



$$H_3C-C(CH_3)=C(CH_3)-CH_3$$

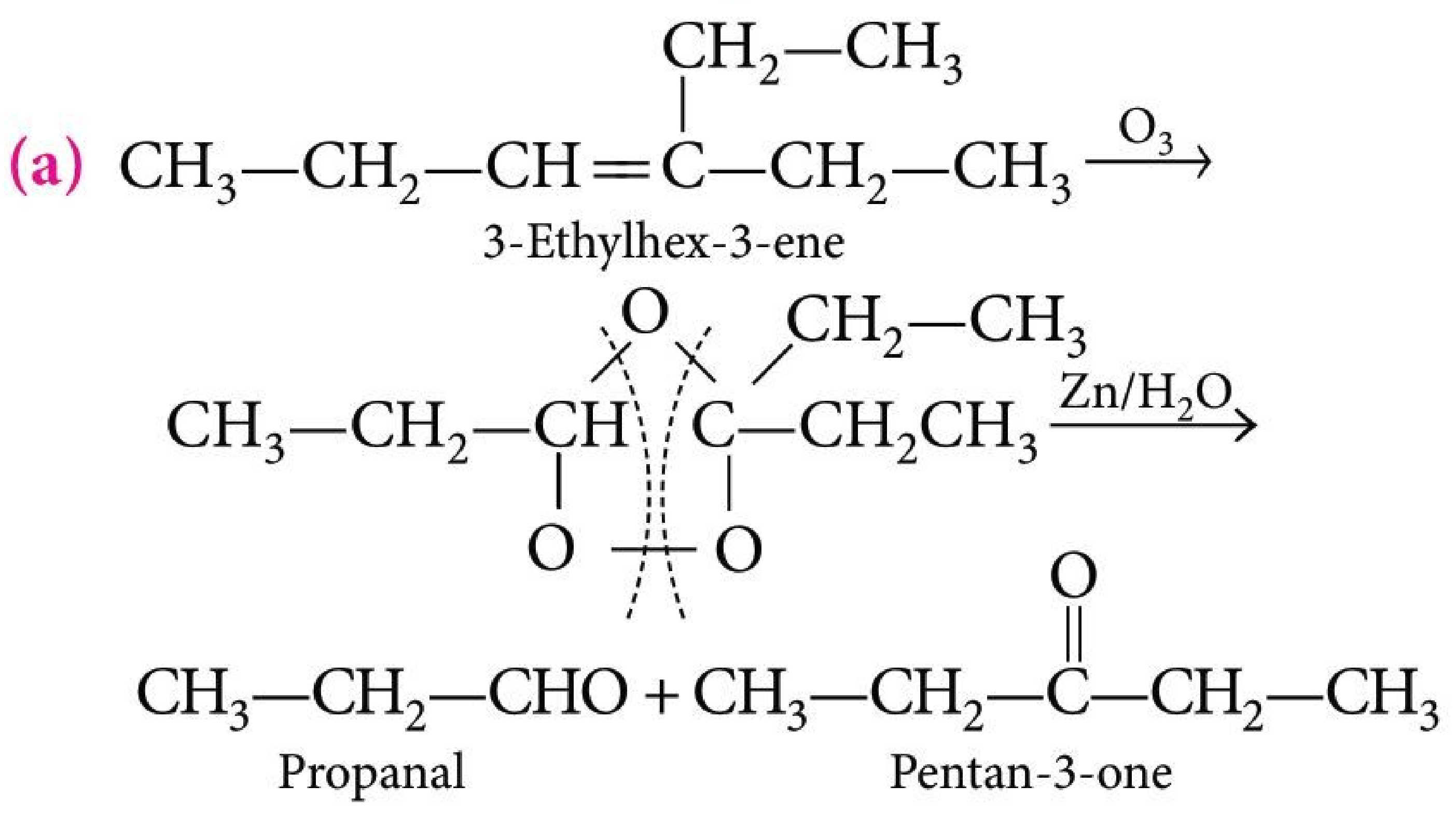
2,3-Dimethylbut-2-ene

34.

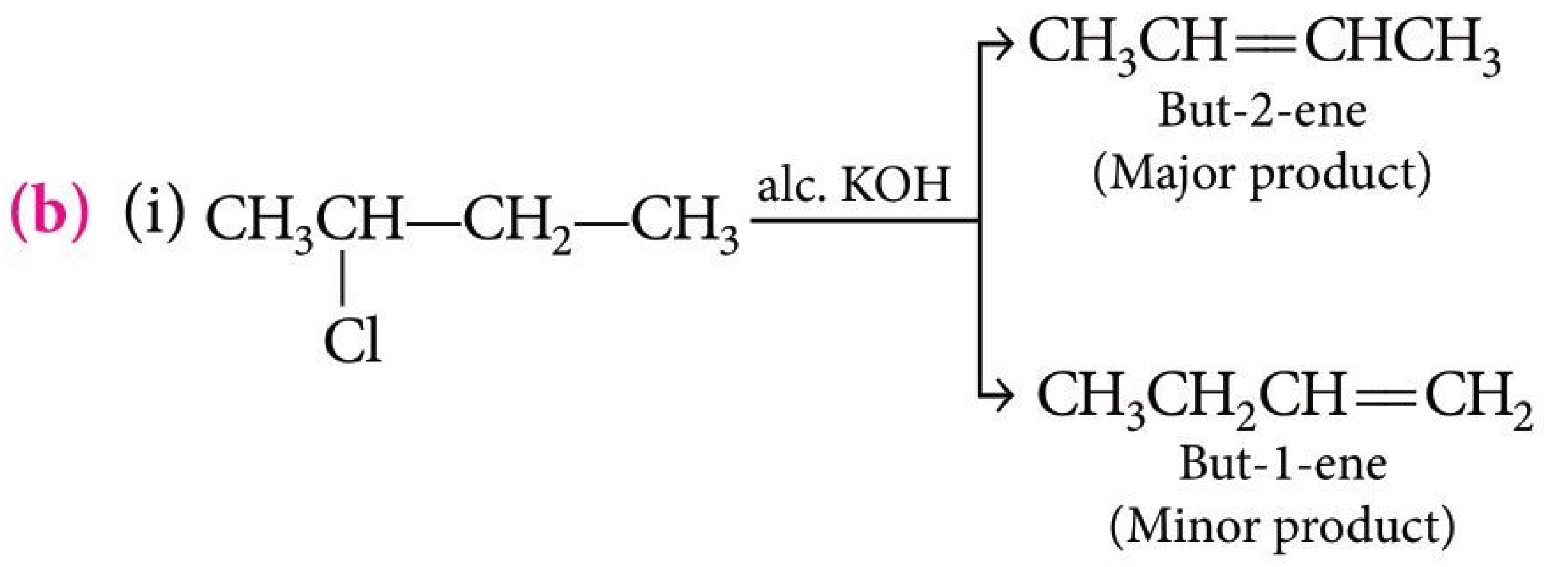

$CaC_2 + 2H_2O \longrightarrow Ca(OH)_2 + C_2H_2$
(A)
Red hot Fe-tube
(B)
Cl_2
anhy. $AlCl_3$
Cl
(C)
$COCH_3$
Anhy. $AlCl_3$
CH_3COCl
(D)
(B)
Conc. H_2SO_4
Δ
SO_3H
(E)

OR

(a)


$CH_3-CH_2-CH=C(CH_2-CH_3)-CH_2-CH_3$
O_3
3-Ethylhex-3-ene
CH_3-CH_2-CH
CH_2-CH_3
$C-CH_2CH_3$
O
Zn/H_2O
$CH_3-CH_2-CHO + CH_3-CH_2-C(=O)-CH_2-CH_3$
Propanal
Pentan-3-one

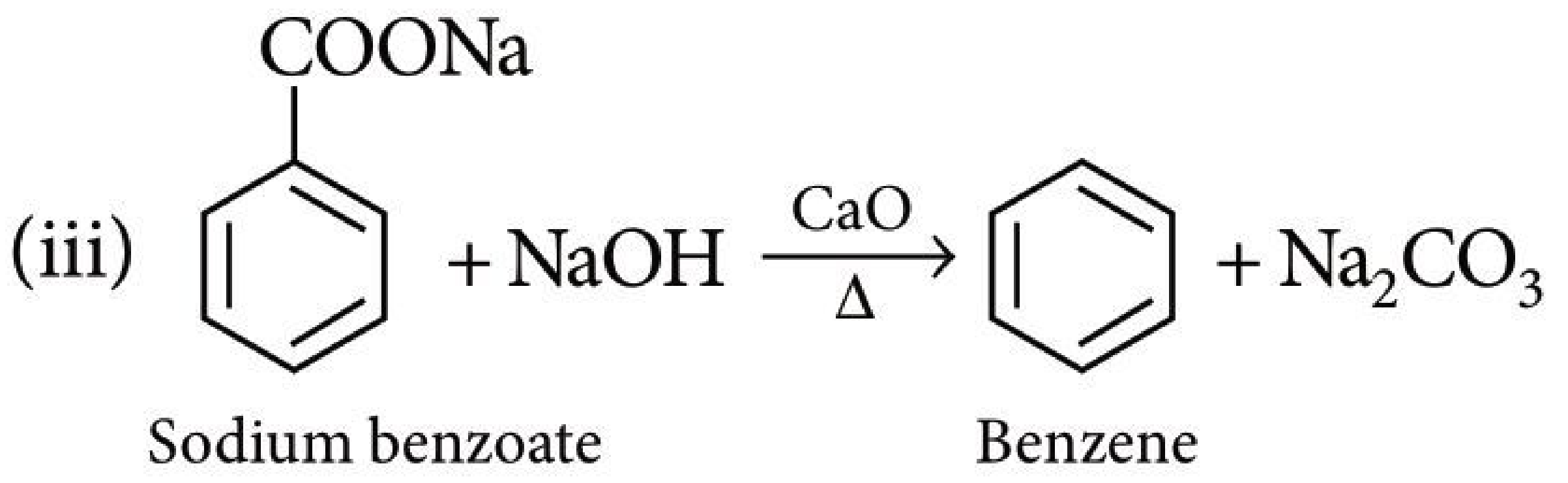
(b) (i)


$CH_3CH(Cl)-CH_2-CH_3$
alc. KOH
$CH_3CH=CHCH_3$
But-2-ene
(Major product)
$CH_3CH_2CH=CH_2$
But-1-ene
(Minor product)

(ii) $CH_3-CH_2-Br + Mg \xrightarrow{\text{Dry ether}} CH_3-CH_2-MgBr$

Bromoethane — Ethyl magnesium bromide

(iii)

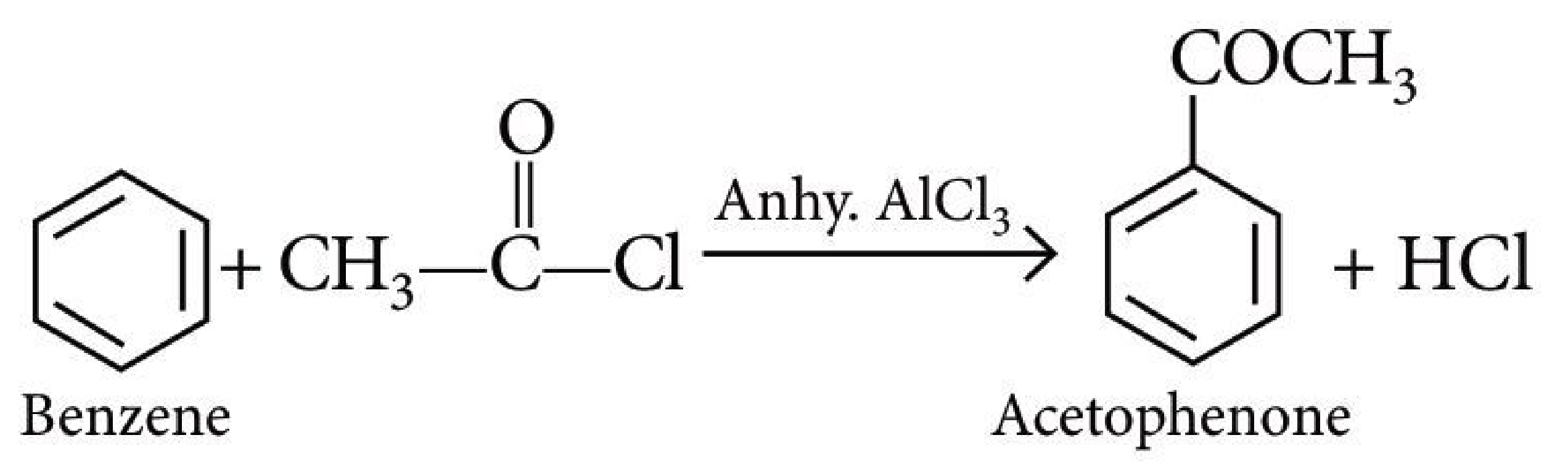

COONa
+ NaOH
CaO
Δ
$+ Na_2CO_3$
Sodium benzoate
Benzene

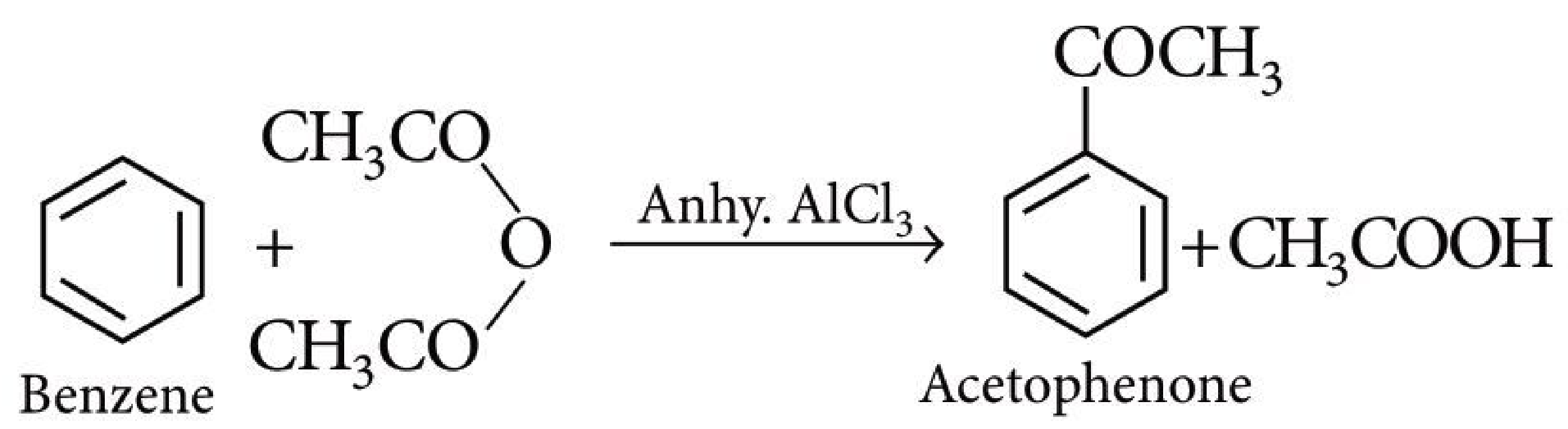
35. (a) Nucleophiles are nucleus loving chemical species. Since the nucleus of any atom is positively charged, therefore, nucleophiles must be electron rich chemical species containing at least one lone pair of electrons. Examples : H^-, CN^-, NO_2^-, $H_2\ddot{O}\colon$, $\ddot{N}H_3$, $R-\underset{\cdot\cdot}{\ddot{O}}-H$, etc.

(b) (i) Kolbe's reaction : In this reaction, an aqueous solution of sodium or potassium salt of carboxylic acid on electrolysis gives alkane having even number of carbon atoms at anode.

$$2CH_3COO^-Na^+ + 2H_2O \xrightarrow{\text{electrolysis}} \underset{\text{Ethane}}{CH_3-CH_3} + 2CO_2 + H_2 + 2NaOH$$

(ii) Friedel-Crafts acylation is a Lewis acid catalysed electrophilic aromatic substitution reaction that allows the synthesis of acylated product *via* the reaction of arenes with carboxylic acid chloride or the anhydride. Anhydrous $AlCl_3$ is used as catalyst.



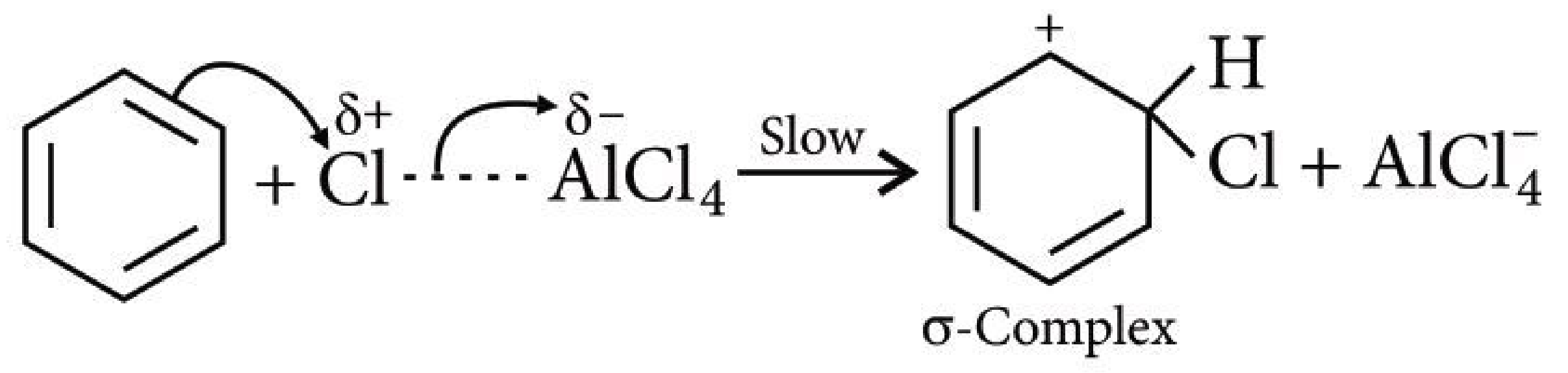


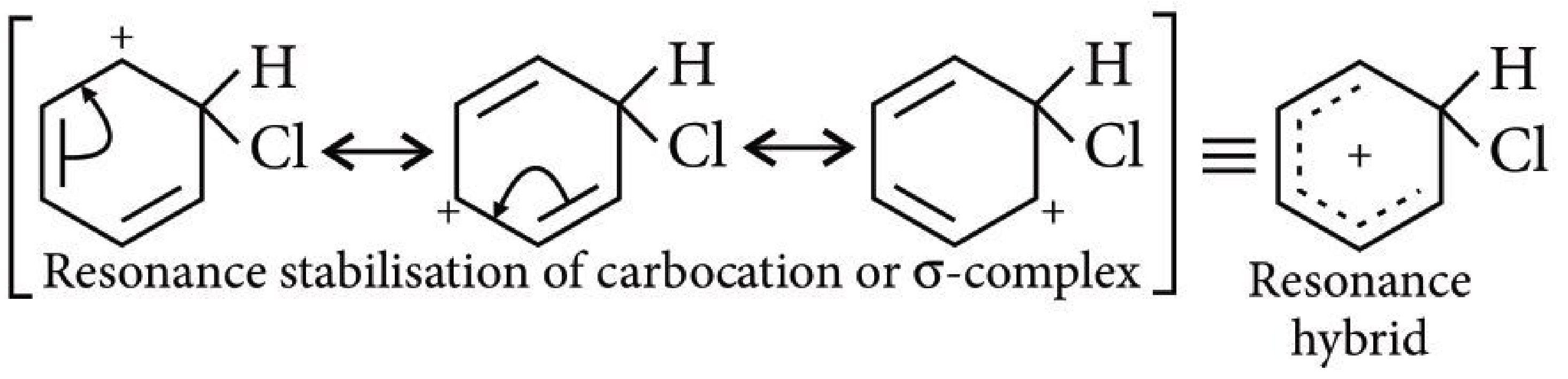
(c) The halogenation of benzene proceeds by the following mechanism :

I : Generation of an electrophile.

$$\underset{\text{Chlorine}}{Cl-Cl} + AlCl_3 \longrightarrow \underset{\text{Electrophile}}{\overset{\delta+}{Cl}\cdots\cdots\overset{\delta-}{AlCl_4}}$$

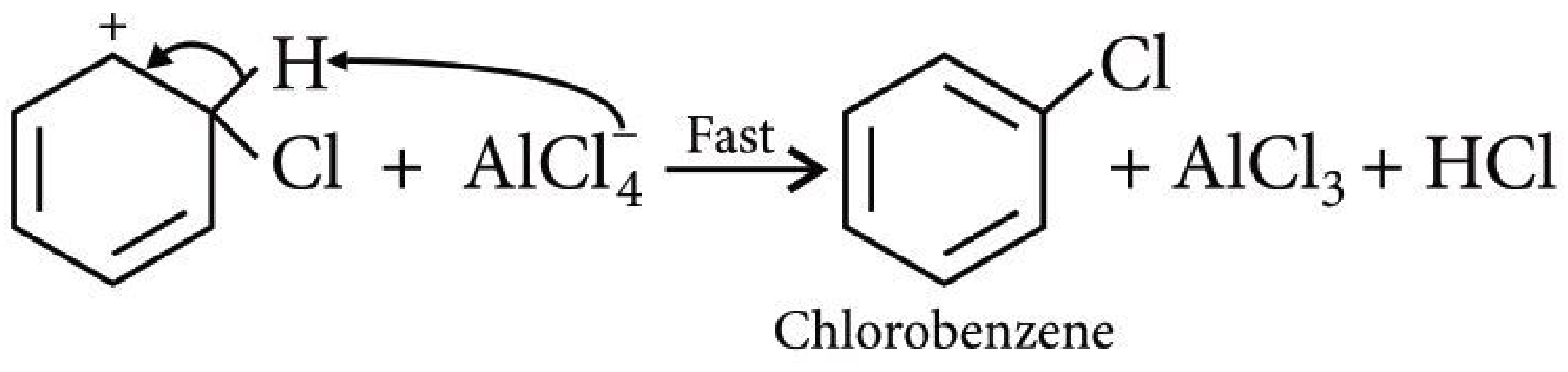
II : Formation of σ-complex or carbocation intermediate.





This step is slow and hence the rate-determining step of the reaction.

III : Loss of a proton from the carbocation intermediate.



This step is fast and hence does not affect the rate of the reaction.

◆◆

Chemistry bulletin

Gold From SIM Cards Can Be Reused to Manufacture Drugs

The method for extracting gold from electronic waste such as sim cards etc., was developed by researchers at the University of Cagliari in Italy and the process for using the recovered gold was developed by researchers at Imperial College London. The study is published in ACS Sustainable Chemistry & Engineering.

Re-using gold from electronic waste prevents it from being lost to landfill, and using this reclaimed gold can definitely reduce the need to mine new materials.

Waste Electrical and Electronic Equipment (WEEE) is very difficult to separate and break down for extracting their individual components. These processes usually involve tons of energy and harsh chemicals. All the electronic items usually end up in landfills and dumps because it doesn't make financial sense to invest in extracting individual components. However, these electrical and electronic equipment do indeed contain numerous metals that manufacturers could repurpose for various additional products.

The lead researcher Professor James Wilton-Ely, from the Department of Chemistry at Imperial College London, in a university press release said "It is shocking that most of our electronic waste goes to landfill and this is the opposite of what we should be doing to curate our precious elemental resources. Our approach aims to reduce the waste already within our communities and make it a valuable resource for new catalysts, thereby also reducing our dependence on environmentally damaging mining practices,".

"We are currently paying to get rid of electronic waste, but processes like ours can help reframe this 'waste' as a resource. Even SIM cards, which we routinely discard, have a value and can be used to reduce reliance on mining and this approach has the potential to improve the sustainability of processes such as drug manufacture."

However, the gold sourced from this process cannot be re-used for electronics. So, the Imperial team developed a way to use it as a catalyst in the manufacturing of drugs. In recent years, gold-catalyzed cross-coupling reactions have emerged as a powerful technique for the synthesis of biaryl compounds.

Thus, the existing cationic gold (I) and neutral gold (III) derived from environmentally damaging gold mining can be replaced with more sustainable and cheaper alternative recovered from tonnes of e-waste currently sent to land fill each year.

GET SET GO for NEET

Exam on
7th May 2023

Class XII

with exclusive and brain storming MCQs

Practicing these MCQs help to strengthen your concepts and give you extra edge in your NEET preparation

1. If ϕ denotes reduction potential, then which of the following options is true?
   (a) $E^\circ_{cell} = \phi_{right} - \phi_{left}$
   (b) $E^\circ_{cell} = \phi_{left} + \phi_{right}$
   (c) $E^\circ_{cell} = \phi_{left} - \phi_{right}$
   (d) $E^\circ_{cell} = -(\phi_{left} + \phi_{right})$

2. The differential rate law for the reaction, $H_2 + I_2 \rightarrow 2HI$ is
   (a) $-\frac{d[H_2]}{dt} = -\frac{d[I_2]}{dt} = -\frac{d[HI]}{dt}$
   (b) $\frac{d[H_2]}{dt} = \frac{d[I_2]}{dt} = \frac{1}{2}\frac{d[HI]}{dt}$
   (c) $\frac{1}{2}\frac{d[H_2]}{dt} = \frac{1}{2}\frac{d[I_2]}{dt} = -\frac{d[HI]}{dt}$
   (d) $-2\frac{d[H_2]}{dt} = -2\frac{d[I_2]}{dt} = \frac{d[HI]}{dt}$

3. Amongst the following, the species with an atom in +6 oxidation state is
   (a) MnO_4^- (b) $Cr(CN)_6^{3-}$
   (c) NiF_6^{2-} (d) CrO_2Cl_2

4. Identify the correct sequence of increasing number of π-bonds in structures of the following molecules.
   I. $H_2S_2O_6$ II. H_2SO_3
   III. $H_2S_2O_5$
   (a) I, II, III (b) II, III, I
   (c) II, I, III (d) I, III, II

5. A unit cell of sodium chloride has four formula units. The edge length of the unit cell is 0.564 nm. What is the density of sodium chloride?
   (a) 1.2 g/cm^3 (b) 2.16 g/cm^3
   (c) 3.64 g/cm^3 (d) 4.56 g/cm^3

6. Raoult's Law is obeyed by a binary liquid solution when
   (a) the forces of attractions between like molecules are greater than those between unlike molecules
   (b) the forces of attractions between like molecules are smaller than those between unlike molecules
   (c) the forces of attractions between like molecules are more or less identical with those between unlike molecules
   (d) the volume occupied by unlike molecules are different.

7. The iron obtained from the blast furnace contains 4%
   (a) phosphorus (b) sulphur
   (c) magnesium (d) carbon.

8. The structure of diamagnetic nickel complex, $[Ni(CN)_4]^{2-}$ is

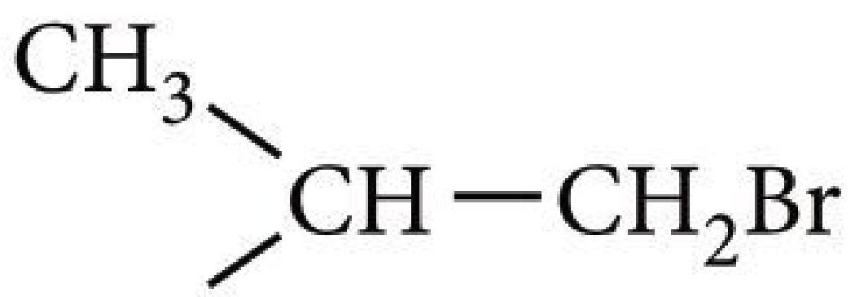
(a) trigonal bipyramidal

(b) tetrahedral

(c) square planar

(d) distorted octahedral.

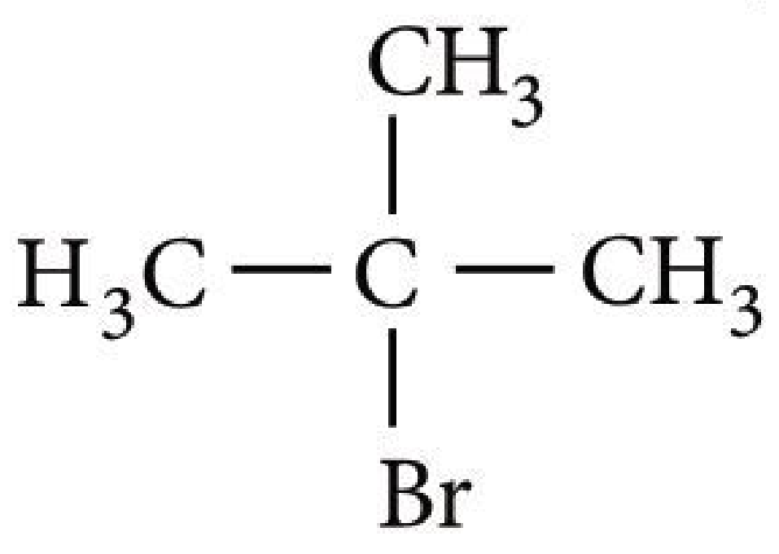
9. Arrange the following compounds in increasing order of their boiling points.



(I)

$CH_3CH_2CH_2CH_2Br$

(II)



(III)

(a) (II) < (I) < (III) (b) (I) < (II) < (III)

(c) (III) < (I) < (II) (d) (III) < (II) < (I)

10. Identify '*X*':

Methyl magnesium bromide + $X \longrightarrow$ 2-Methylpropan-2-ol

(a) Propanol (b) Ethanol

(c) Propanone (d) Butane

11. Which of the following reactions involves the formation of a methyl ester from a carboxylic acid?

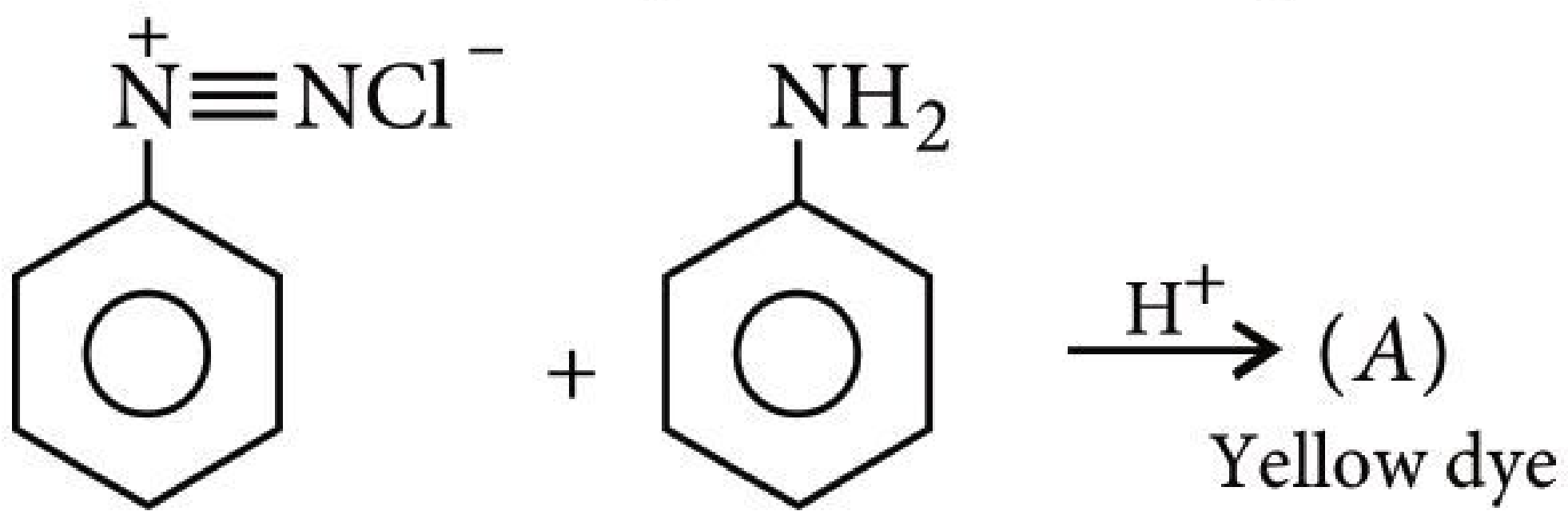
(a) Hell-Volhard-Zelinsky reaction

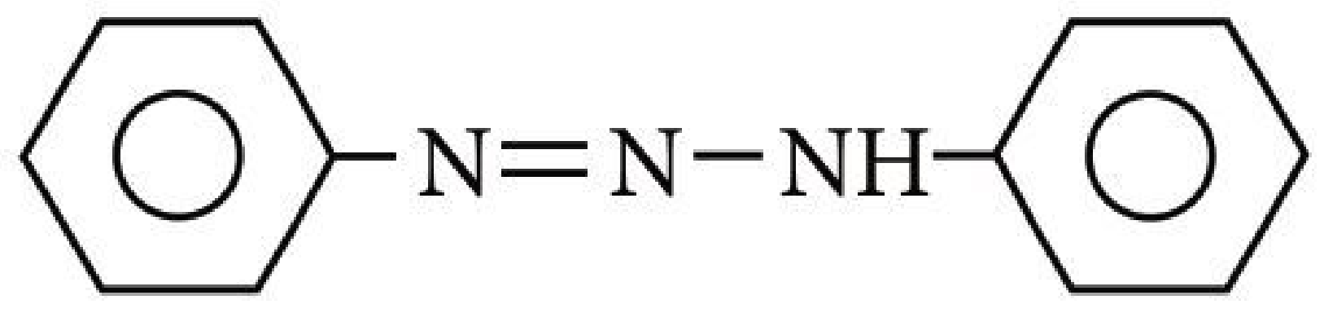
(b) Hunsdiecker reaction

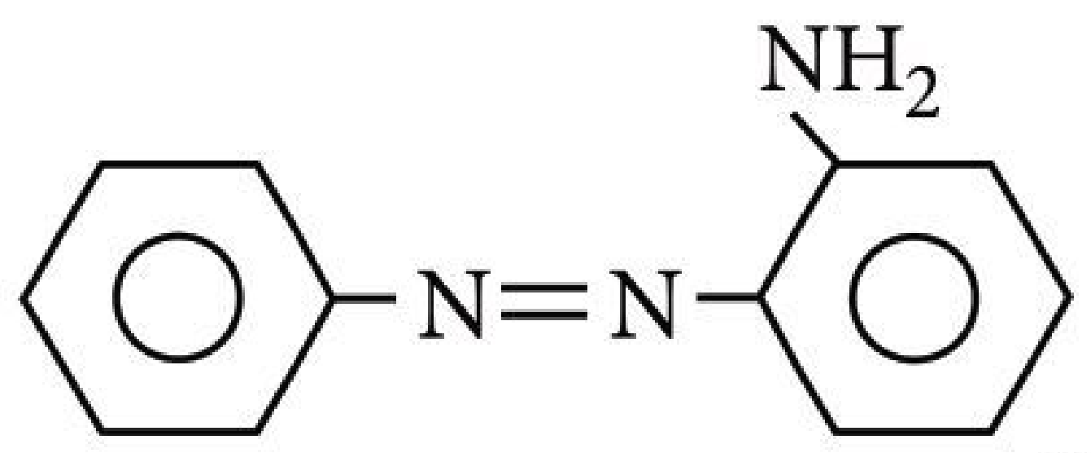
(c) Reaction with ammonia

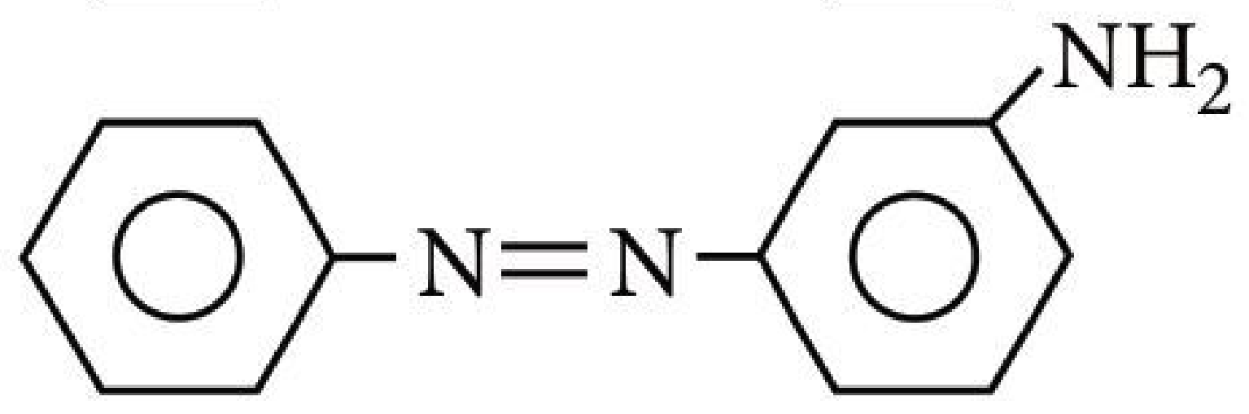
(d) Reaction with alcohol

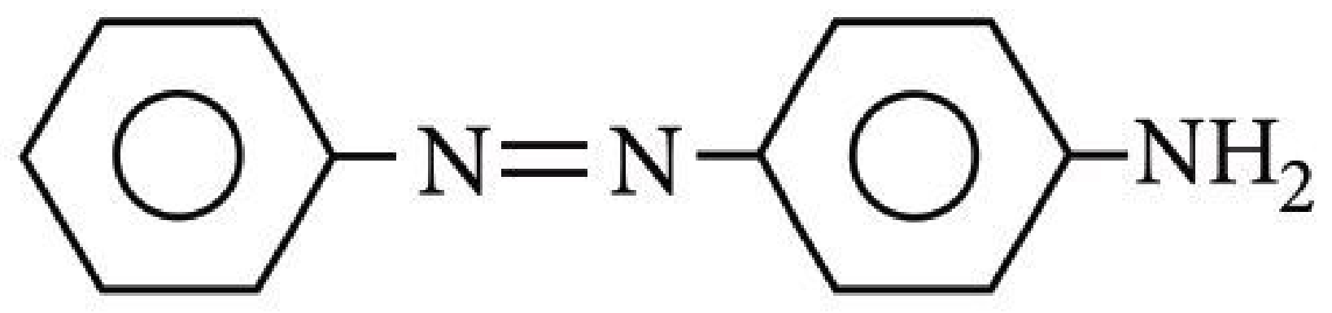
12. In the following reaction, the product (*A*) is



(a) 

(b) 

(c) 

(d) 

13. The α- and β- forms of glucose are

(a) isomers of *D*(+)-glucose and *L*(–)-glucose respectively

(b) diastereomers of glucose

(c) anomers of glucose

(d) isomers which differ in the configuration of C-2

14. Dacron is continuous filament yarn used in curtains, dress fabrics and pressure fire hoses. The reaction for preparing dacron is by the combination of which of the following?

(a) Hexamethylene diamine and adipic acid

(b) Caprolactam

(c) Phenol and formaldehyde

(d) Ethylene glycol and terephthalic acid

15. Among the following compounds, the only one which is not an artificial sweetening agent is

(a) aspartame (b) sucrose

(b) sucralose (d) saccharin.

SOLUTIONS

1. **(a)**

2. **(d):** $H_2 + I_2 \rightarrow 2HI$

When 1 mole of H_2 and 1 mole of I_2 react, 2 moles of HI are formed in the same time interval.

Thus the rate may be expressed as

$$\frac{-d[H_2]}{dt} = \frac{-d[I_2]}{dt} = \frac{1}{2}\frac{d[HI]}{dt}$$

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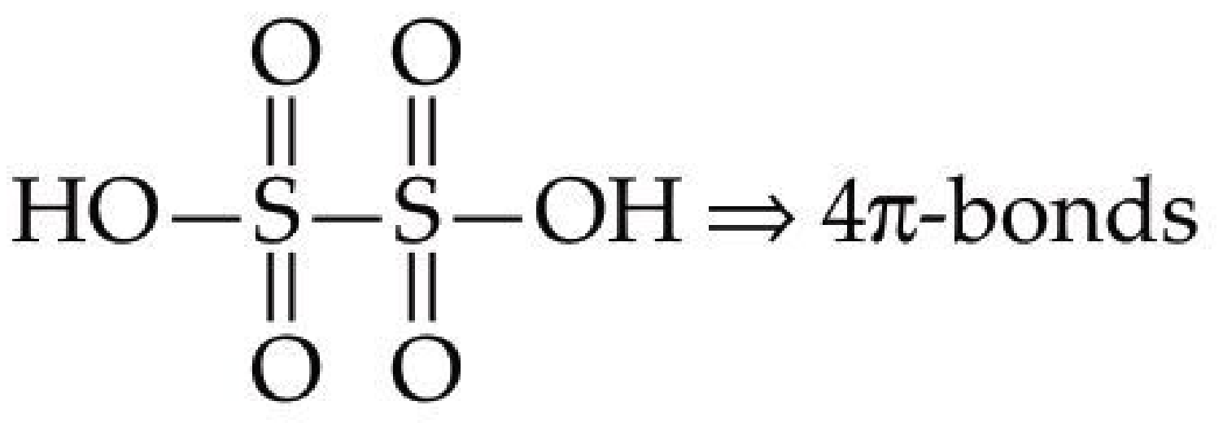
or

$$\frac{-2d[H_2]}{dt} = \frac{-2d[I_2]}{dt} = \frac{d[HI]}{dt}$$

The negative sign signifies a decrease in concentration of the reactant with increase of time.

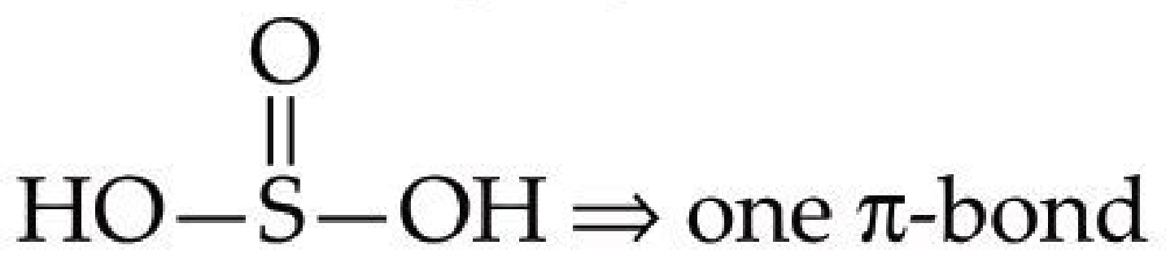
3. **(d):** MnO_4^-, Oxidation state of Mn = +7
$Cr(CN)_6^{3-}$, Oxidation state of Cr = +3
NiF_6^{2-}, Oxidation state of Ni = +4
CrO_2Cl_2, Oxidation state of Cr = +6

4. **(b):** (I) $H_2S_2O_6$,



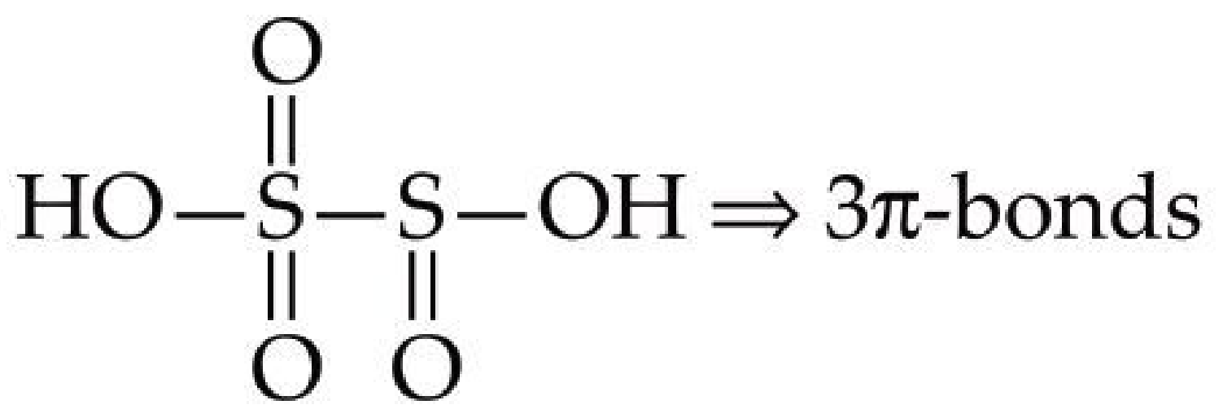
$$HO-\overset{\overset{O}{\|}}{\underset{\underset{O}{\|}}{S}}-\overset{\overset{O}{\|}}{\underset{\underset{O}{\|}}{S}}-OH \Rightarrow 4\pi\text{-bonds}$$

(II) H_2SO_3,



$$HO-\overset{\overset{O}{\|}}{S}-OH \Rightarrow \text{one } \pi\text{-bond}$$

(III) $H_2S_2O_5$,



$$HO-\overset{\overset{O}{\|}}{\underset{\underset{O}{\|}}{S}}-\underset{\underset{O}{\|}}{S}-OH \Rightarrow 3\pi\text{-bonds}$$

5. **(b):** $$\text{Density} = \frac{Z \times M}{N_A \times a^3}$$

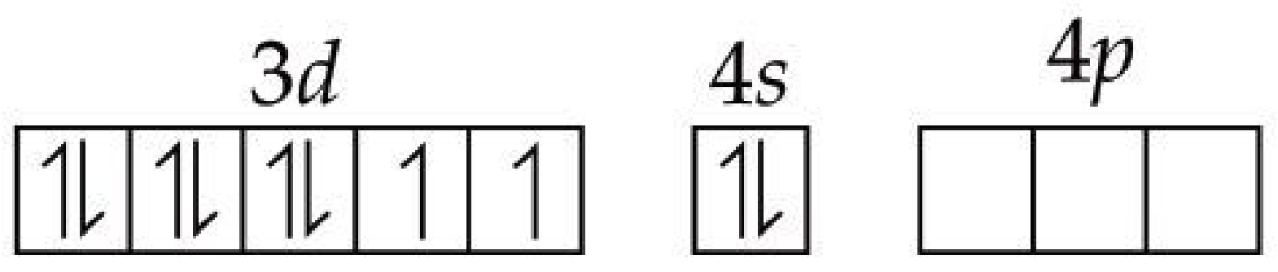
$$= \frac{4 \times 58.5}{6.023 \times 10^{23} \times (5.64 \times 10^{-8})^3} = 2.16 \text{ g/cm}^3$$

6. **(c):** Ideal solutions obey Raoult's law where the intermolecular interactions between the different components (*A* – *B* interactions) are of the same magnitude as the intermolecular interactions found in the pure components (*A* – *A* and *B* – *B* interactions).

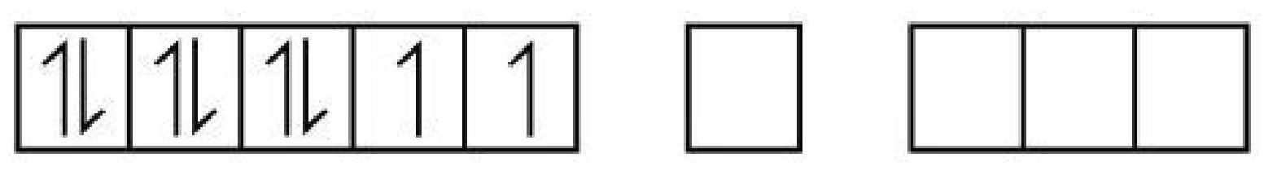
7. **(d):** Iron obtained from blast furnace consists of 93% iron, 3.5-4.5% carbon and rest silicon. This mixture is known as pig iron.

8. **(c):** In complex $[Ni(CN)_4]^{2-}$

$_{28}Ni$ (ground state) :

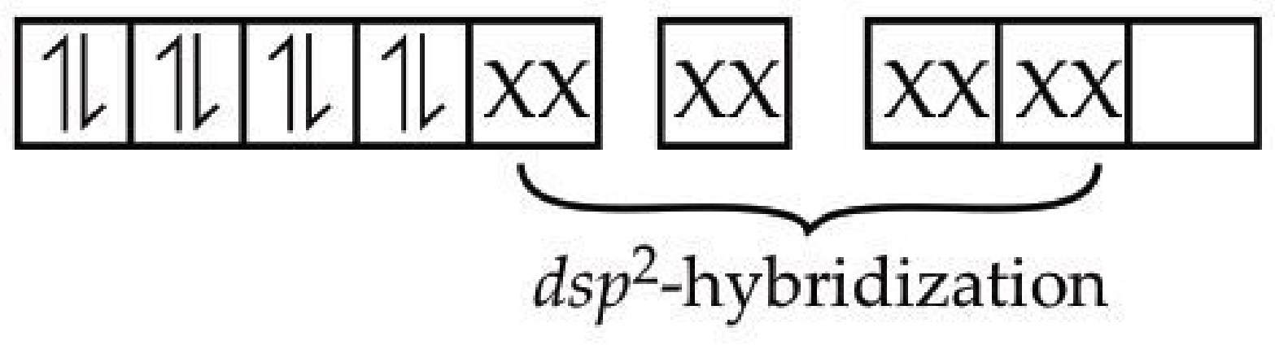


Ni^{2+} ion :



Pairing will take place due to the presence of strong field ligand.

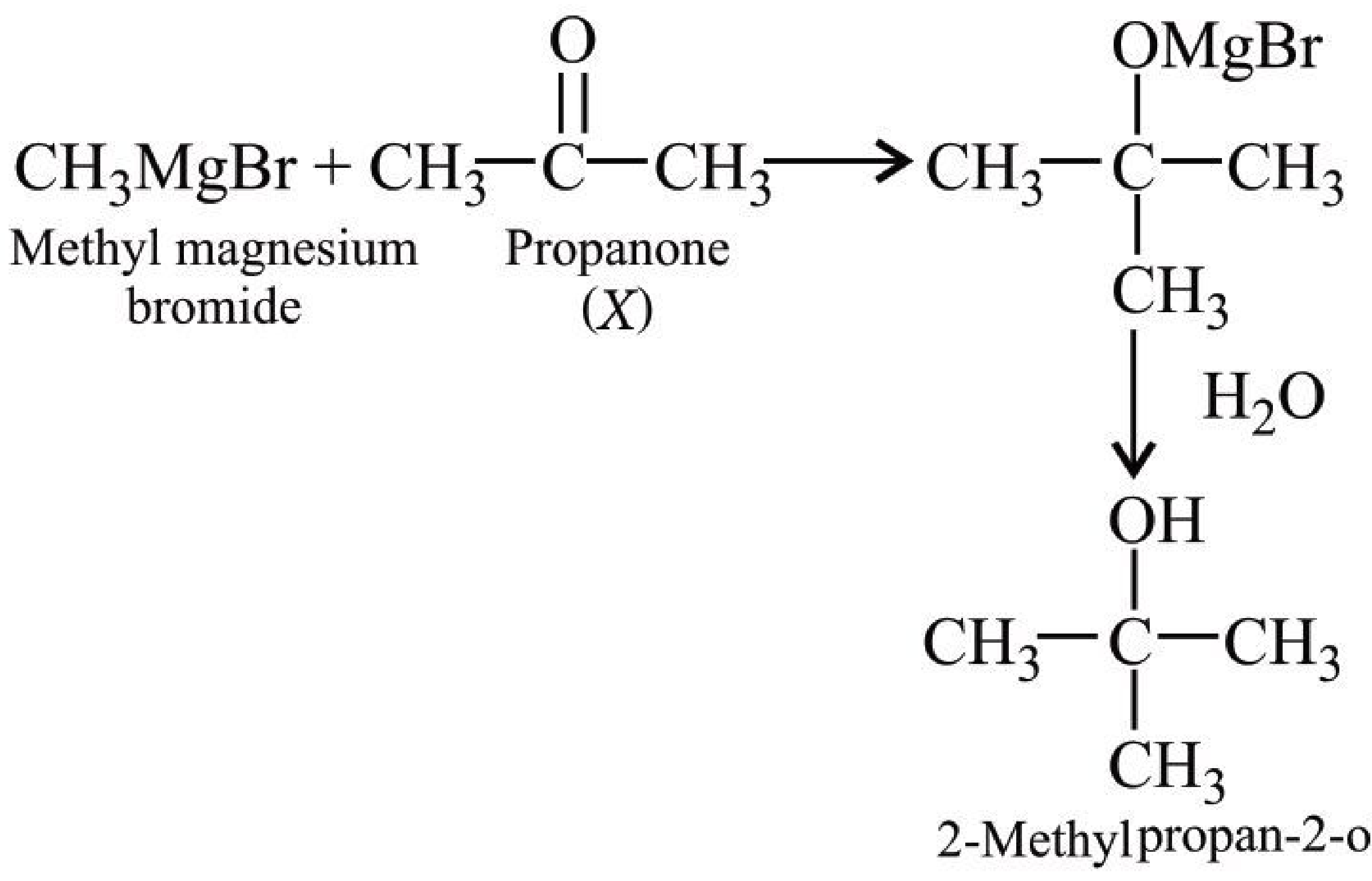
Ni^{2+} hybridized state :


⥮ ⥮ ⥮ ⥮ xx
xx
xx xx
dsp²-hybridization

Here, CN^- is a strong ligand and as it approaches the metal ion, the electrons in 3*d*-orbitals pair up. Hence, the shape is square planar.

9. **(c):** Boiling point increases as the branching decreases.

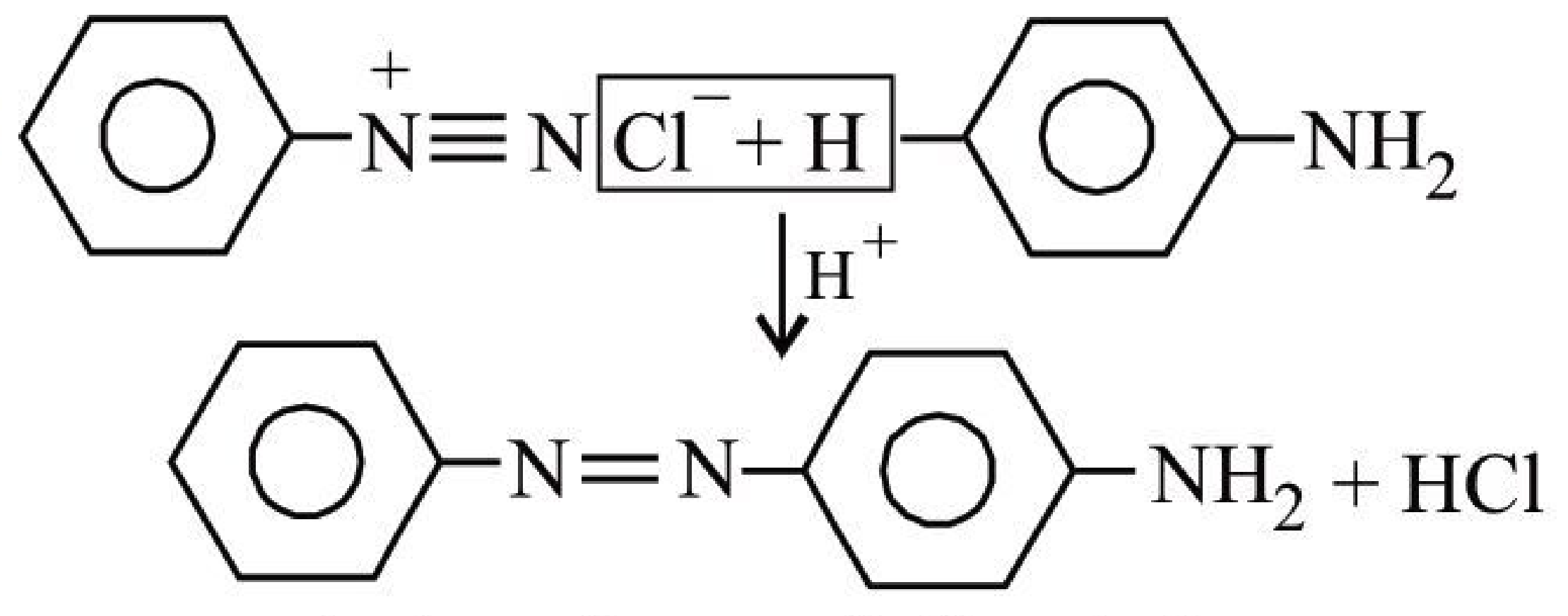
10. **(c):**


CH₃MgBr + CH₃–C(=O)–CH₃ → CH₃–C(OMgBr)(CH₃)–CH₃
Methyl magnesium bromide
Propanone (X)
H₂O
CH₃–C(OH)(CH₃)–CH₃
2-Methylpropan-2-ol

11. **(d):** Alcohols undergo reaction with carboxylic acids to give esters.

$$\underset{\text{Acid}}{R-COOH} + \underset{\text{Methyl alcohol}}{CH_3OH} \xrightarrow{\Delta} \underset{\text{Ester}}{R-COOCH_3} + H_2O$$

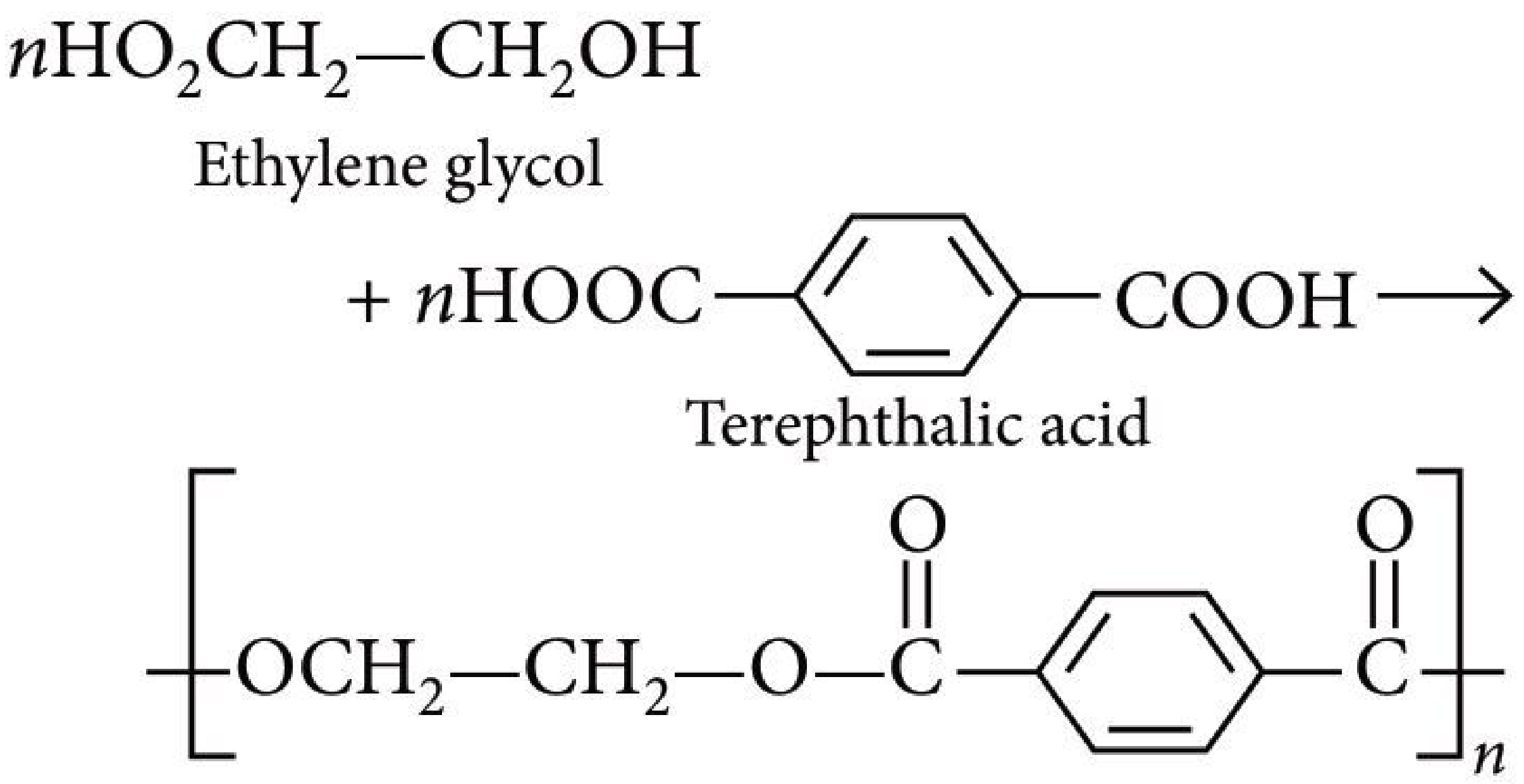
12. **(d):**


N≡N Cl⁻ + H
NH₂
H⁺
N=N
NH₂ + HCl

p-Aminoazobenzene (yellow dye)
(*A*)

13. **(c)**

14. **(d):**

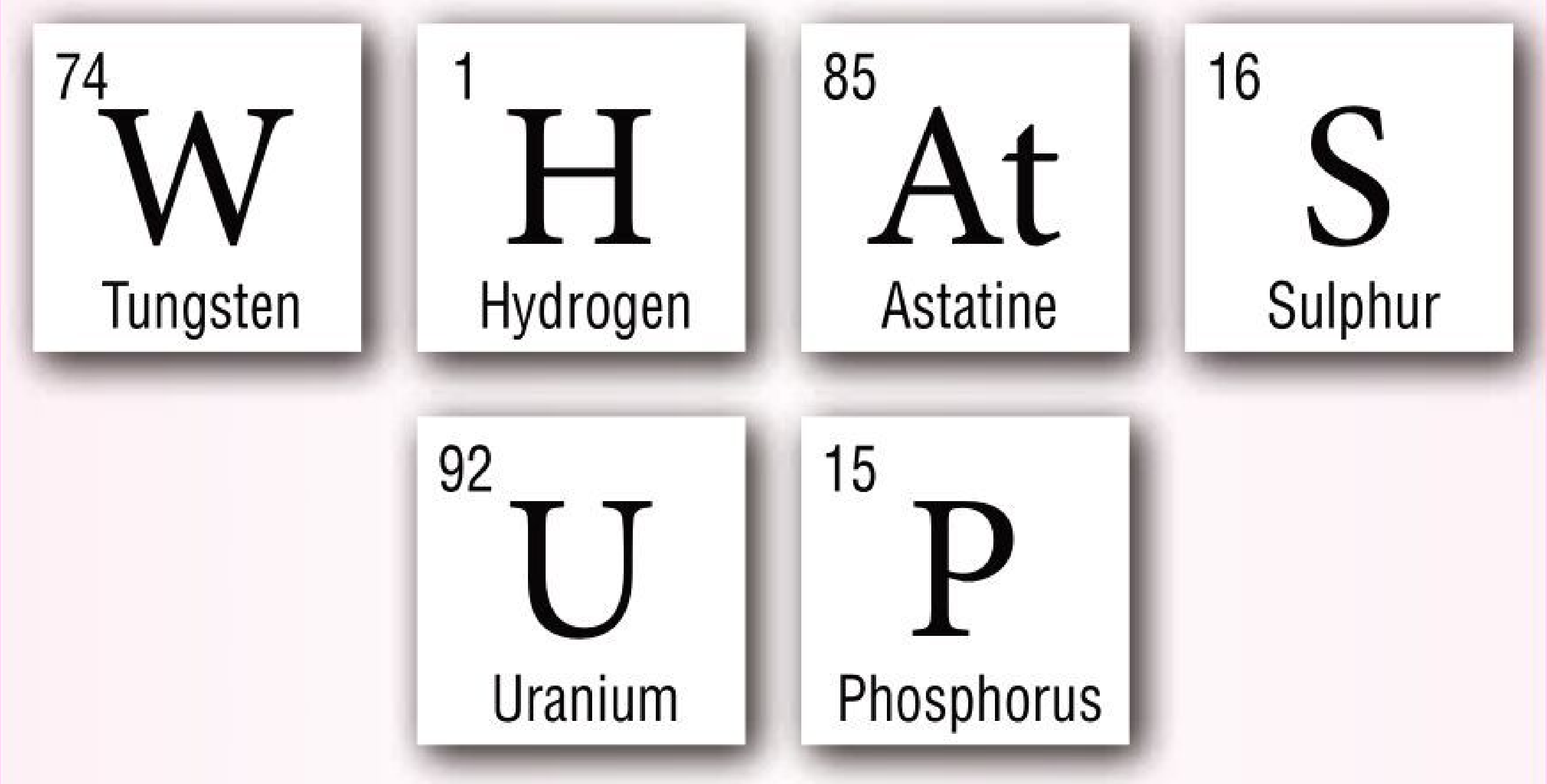

nHO₂CH₂—CH₂OH
Ethylene glycol
+ nHOOC—C₆H₄—COOH →
Terephthalic acid
[OCH₂—CH₂—O—C(=O)—C₆H₄—C(=O)]ₙ

Terylene or dacron

15. **(b):** Sucrose is a natural sweetener.

◆◆

COMIC CAPSULE


74 W Tungsten
1 H Hydrogen
85 At Astatine
16 S Sulphur
92 U Uranium
15 P Phosphorus

CLASS-XII

BRUSH UP for NEET/JEE

Brush up your concepts to get high rank in NEET/JEE (Main and Advanced) by reading this column. This specially designed column is updated year after year by a panel of highly qualified teaching experts well-tuned to the requirements of these Entrance Tests.

Unit 5 Coordination Compounds

Addition compounds : These are the compounds formed by combination of two or more simple compounds. They are of two types :

- **Double salt :** A compound formed by combination of two or more simple compounds, which is stable in solid state only is called a *double salt*. In solution, it breaks into component ions.

  e.g., $K_2SO_4{\cdot}Al_2(SO_4)_3{\cdot}24H_2O$; Potash alum
  $FeSO_4{\cdot}(NH_4)_2SO_4{\cdot}6H_2O$; Mohr's salt
  $KCl{\cdot}MgCl_2{\cdot}6H_2O$; Carnallite
- **Complex compound :** A compound formed by combination of two or more simple compounds which retain its identity in both solid and solution states is called *complex compound*.

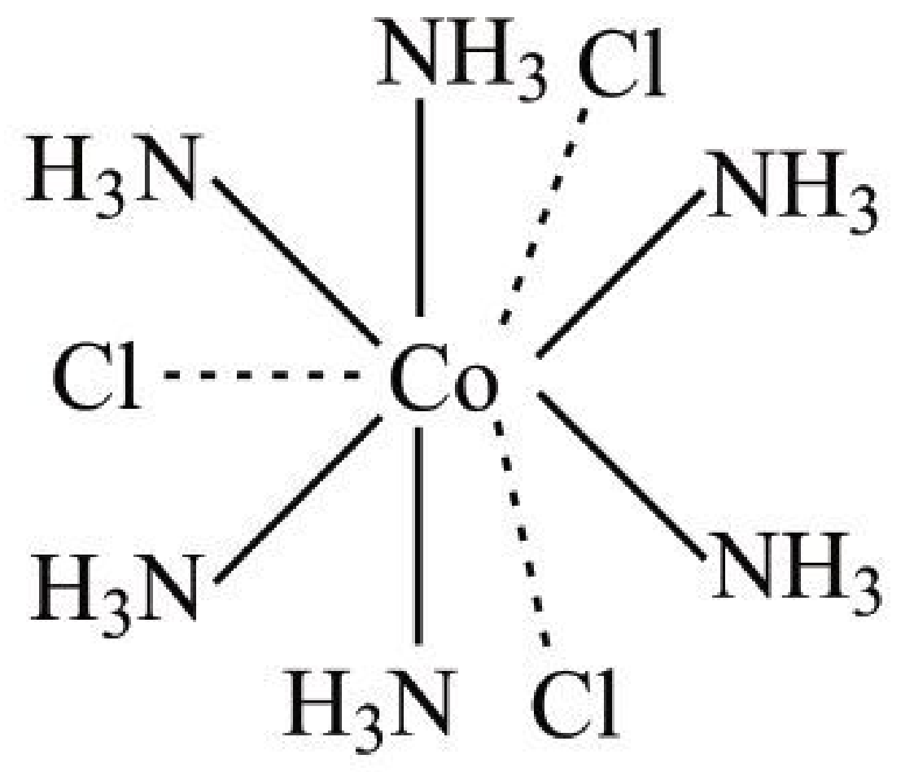
  e.g., $K_4[Fe(CN)_6]$ Potassium ferrocyanide

Complex compounds are explained by many theories like Werner's, VBT and crystal field theory.

WERNER'S COORDINATION THEORY

- It explains the nature of bonding in complexes. According to Alfred Werner, metal show two different kinds of valencies:
  - **Primary valency :** Non-directional and ionisable. It is equal to the oxidation state of the central metal ion.
  - **Secondary valency :** Directional and non-ionisable. It is equal to the coordination number of the metal. It is commonly satisfied by neutral and negatively charged or some times by positively charged ligands.
- The ionisation of the coordination compound is written as :

  $[Co(NH_3)_6]Cl_3 \rightleftharpoons [Co(NH_3)_6]^{3+} + 3Cl^-$



$[Co(NH_3)_6]Cl_3$

Representation of $CoCl_3\cdot 6NH_3$ complex according to Werner's theory

The table below shows few Werner's coordination compounds :

	Werner complex and colour	Modern notation	Ionisation	Primary valency satisfied by (ON)	Secondary valency satisfied by CN
(*A*)	$CoCl_3{\cdot}6NH_3$; Yellow	$[Co(NH_3)_6]Cl_3$	$[CoCl(NH_3)_6]^{3+} + 3Cl^-$	$3Cl^-$	$6NH_3$
(*B*)	$CoCl_3{\cdot}5NH_3$; Purple	$[Co(NH_3)_5]Cl_2$	$[CoCl(NH_3)_5]^{3+} + 2Cl^-$	$2Cl^-$	$5NH_3$, one Cl^-
(*C*)	$CoCl_3{\cdot}4NH_3$; Exists in 2 isomers *cis* and *trans* with green and violet colours respectively	$[CoCl_2(NH_3)_4]Cl$	$[CoCl_2(NH_3)_4]^+ + Cl^-$	one Cl^-	$4NH_3$, 2 Cl^-
(*D*)	$CoCl_3{\cdot}3NH_3$; Green	$[CoCl_3(NH_3)_3]$	$[CoCl_3(NH_3)_3]$		$3NH_3$, 3 Cl^-

Note: Conductance of the above complexes will be in the order of $A > B > C > D$.

IMPORTANT TERMS OF COORDINATION COMPOUNDS

Coordination Entity

The central metal atom or ion and ligand taken together is called *coordination entity*. It may be positive, negative or neutral.

e.g., $[Cu(NH_3)_4]^{2+}$, $[Fe(CN)_6]^{4-}$, $[Ni(CO)_4]$

Central Atom

The atom or ion with which definite number of ligands are attached in a definite geometry is called *central atom/ion*. Any atom/ion which has high positive charge density or vacant orbitals of suitable energy may be central atom or ion. *e.g.,* transition metals, lanthanoids. It is a Lewis acid (electron acceptor).

Ligands

Molecules or ions which are bound to the central atom/ion in the coordination entity are called *ligands*. A molecule or ion which has high negative charge or dipole or lone pair of electrons may be ligands. It is Lewis base (electron donor).

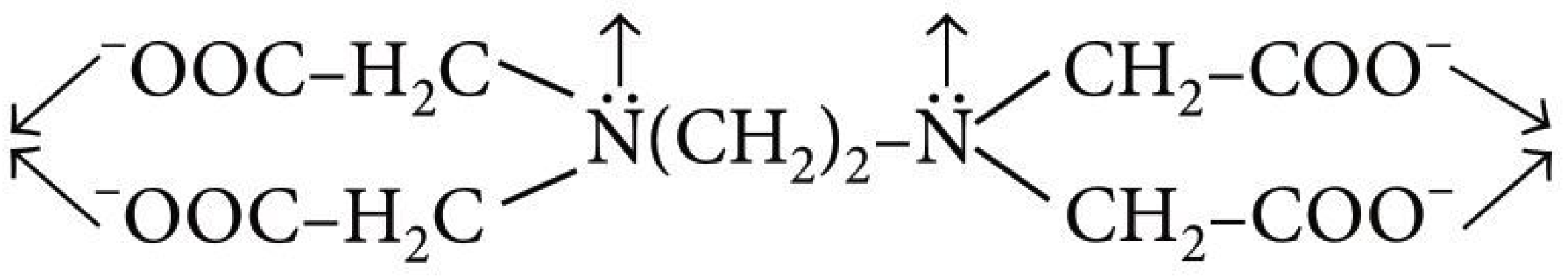
Classification of ligands :

Ligands

- **On the basis of charge**
  - **Negative ligands** CN^-, F^-, Cl^-, NO_2^-, NO_3^-, OH^-, O^{2-}
  - **Positive ligands** NO_2^+, NO^+, $N_2H_5^+$
  - **Neutral ligands** $H_2\ddot{O}$, $\ddot{N}H_3$, CO, NH_2OH, $CH_3\ddot{N}H_2$
- **On the basis of number of donor sites**
  - **Monodentate :** Only one donor site *e.g.*, H_2O, NH_3
  - **Bidentate :** Two donor sites *e.g.*, $(COO^-)_2$ (Oxalato), CH_2-NH_2 | CH_2-NH_2 (Ethylenediamine)
  - **Polydentate :** More than two donor sites *e.g.*, EDTA (Hexadentate)
- **On the basis of bonding**
  - **Chelating ligands :** A bidentate or polydentate ligand which forms more than one coordinate bonds in such a way that a ring is formed.
    CH_2-NH_2 | CH_2-NH_2 (Ethylenediamine)
  - **Ambidentate ligands :** Monodentate ligand which contains more than one coordinating atom (or donor atom).
    $M \leftarrow SCN$ or $M \leftarrow NCS$, $M \leftarrow CN$ or $M \leftarrow NC$

Polydentate or multidentate ligands : These ligands coordinate using two or more donor atoms.

- **Bidentate ligands:** Ethylenediamine(*en*) $H_2\overset{\uparrow}{\ddot{N}}(CH_2)_2\overset{\uparrow}{\ddot{N}}H_2$ and
- **Tridentate or terdentate ligands :** Diethylenetriamine (diene) :
  $H_2\overset{\uparrow}{\ddot{N}}(CH_2)_2\overset{\uparrow}{\ddot{N}}H(CH_2)_2\overset{\uparrow}{\ddot{N}}H_2$
- **Tetradentate ligand :** Triethylenetetraamine (triene):
  $H_2\overset{\uparrow}{\ddot{N}}(CH_2)_2\overset{\uparrow}{\ddot{N}}H(CH_2)_2\overset{\uparrow}{\ddot{N}}H(CH_2)_2\overset{\uparrow}{\ddot{N}}H_2$
- **Pentadentate ligand :** Tetraethylenepentaamine (tetraene):
  $\overset{\uparrow}{\ddot{N}}H_2(CH_2)_2\overset{\uparrow}{\ddot{N}}H(CH_2)_2\overset{\uparrow}{\ddot{N}}H(CH_2)_2\overset{\uparrow}{\ddot{N}}H(CH_2)_2\overset{\uparrow}{\ddot{N}}H_2$
- **Hexadentate ligand :** Ethylene diaminetetraacetato ion:



- **Flexidentate ligands :** Ligands which have more than one donor site, like SO_4^{2-}, CO_3^{2-} etc. When these ligands get coordinated to the metal atom or ion, they give rise to the formation of two types of complex compounds. In one type, they get linked to the metal atom through one donor atom only while in the formation of another type of the complex compound, they get coordinated to the metal atom through both of its donor atoms.
  EDTA generally acts as a hexadentate ligand but it can also act as a pentadentate and tetradentate ligand.

Chelating Effect

- Chelating ligands form more stable complexes than the monodentate due to the following reasons:
- **Formation of rings :** Generally the chelate complexes with 5- or 6-membered rings are more stable. Out of these, 5-membered rings are very stable when they involve saturated ligands, e.g., ethylenediamine which contains 5-membered stable ring structure.
- **Steric hindrance :** Ligands with large groups form unstable rings than the ligands with smaller groups due to steric hindrance.
- **Number of rings :** The complex compound having maximum number of rings formed with the ligands is most stable. For example, a complex $[M(en)_3]^{3+}$ is less stable than $[M\text{EDTA}]^{2-}$. The former has 3 chelate rings while the latter has 5 chelate rings.

Homoleptic and Heteroleptic Complexes

- **Homoleptic complexes :** Complexes in which a metal is bound to only one kind of ligands are called *homoleptic complexes*.
  e.g., $[Co(NH_3)_6]^{3+}$, $[Ti(H_2O)_6]^{3+}$, $[Cu(CN)_4]^{3-}$
- **Heteroleptic complexes :** Complexes in which the central atom is bound to different type of ligands are called *heteroleptic complexes*.
  e.g., $[Co(NH_3)_4Cl_2]$, $K_2[Fe(CN)_5NO]$,

Sidgwick theory and effective atomic number (EAN): In order to explain the stability of complexes. Sidgwick proposed EAN rule. He suggested that a metal ion will continue accepting electron pairs till the total number of electrons in the metal ion (after gaining one lone pair or electrons from the ligands) becomes equal to that of next higher noble gas. This total number of electrons is called EAN of the metal.

EAN = (Atomic number − O.S.) + (2 × coordination number)

For example,

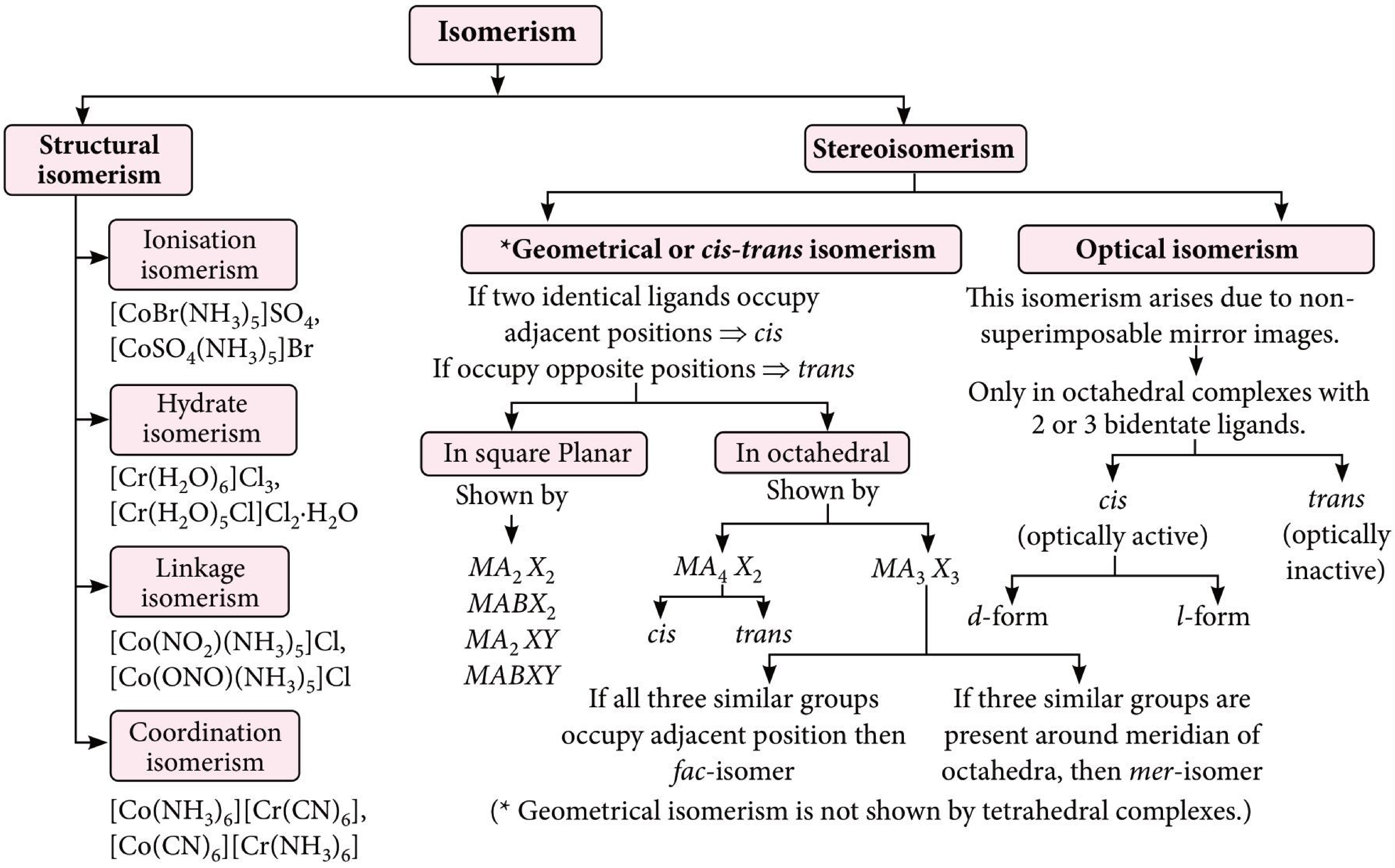
- EAN in $[Fe^{2+}(CN)_6]^{4-} = (26 - 2) + (6 \times 2) = 36$
  $= Z$ of Kr (36) (next nearest inert gas).
- EAN in $[Fe^{3+}(CN)_6]^{3-} = (26 - 3) + (6 \times 2) = 35$
  Z of Kr (36) (next nearest inert gas).

NOMENCLATURE OF COORDINATION COMPOUNDS

- **Rules for writing the formula of coordination compounds :**
  - Formula of the cation whether simple or complex must be written first followed by anion.
  - The coordination sphere is written in square brackets.
  - Within the coordination sphere, the sequence of symbols is, first the metal atom followed by anionic ligand then neutral ligand finally cationic ligand. Ligands of same type are arranged alphabetically.
  - Polyatomic ligands are enclosed in parentheses.
  - The number of cations or anions to be written in the formula is calculated on the basis that total positive charge must be equal to the total negative charge, as the complex as a whole is electrically neutral.
- **Rules for naming coordination compounds :**
  - The cation is named first then the anion.
  - In naming coordination sphere, ligands are named first in alphabetical order followed by metal atom and then oxidation state of metal by a roman numeral in parentheses.
  - Name of a coordination compound is started with a small letter and the complex part is written as one word.
- **Naming of ligands :**
  - Name of anionic ligands end in *–o. e.g.*, Cl^- : Chlorido
  - Neutral ligands (with a few exceptions) retain their names *e.g.*, NH_3 : Ammine
  - Name of cationic ligands end in – *ium. e.g.*, NO_2^+ : Nitronium
  - Certain ligands are represented by abbreviations in parentheses instead of their complex structural formulae. *e.g.*, ethylenediamine(*en*).
  - Ambidentate ligands are named by using different names of ligands or by placing the symbol of donor atom.
    e.g., $—SCN^-$ (Thiocyanato-S or Thiocyanato), $—NCS^-$ (Thiocyanato-N or Isothiocyanato), $—ONO^-$ (Nitrito-O or Nitrito), $—NO_2^-$ (Nitrito-N or Nitro)
  - The prefixes *di-*, *tri-*, *tetra-*, *penta-* and *hexa-* are used to indicate the number of each ligand. If the ligand name includes such a prefix, the ligand name should be placed in parentheses and preceded by *bis*-(2), *tris*-(3), *tetrakis*-(4), *pentakis*-(5) and *hexakis*-(6).
  - When the coordination sphere is anionic, name of central metal ends in *–ate*.

Isomerism in Coordination Compounds

Isomerism : Two or more substances having the same molecular formula but different structural or spatial arrangement are called *isomers* and phenomenon is called *isomerism*.


Isomerism
Structural isomerism
Stereoisomerism
Ionisation isomerism
$[CoBr(NH_3)_5]SO_4$, $[CoSO_4(NH_3)_5]Br$
Hydrate isomerism
$[Cr(H_2O)_6]Cl_3$, $[Cr(H_2O)_5Cl]Cl_2 \cdot H_2O$
Linkage isomerism
$[Co(NO_2)(NH_3)_5]Cl$, $[Co(ONO)(NH_3)_5]Cl$
Coordination isomerism
$[Co(NH_3)_6][Cr(CN)_6]$, $[Co(CN)_6][Cr(NH_3)_6]$
*Geometrical or *cis-trans* isomerism
If two identical ligands occupy adjacent positions ⇒ *cis*
If occupy opposite positions ⇒ *trans*
In square Planar
Shown by
MA_2X_2
$MABX_2$
MA_2XY
$MABXY$
In octahedral
Shown by
MA_4X_2
cis
trans
MA_3X_3
If all three similar groups occupy adjacent position then *fac*-isomer
If three similar groups are present around meridian of octahedra, then *mer*-isomer
Optical isomerism
This isomerism arises due to non-superimposable mirror images.
Only in octahedral complexes with 2 or 3 bidentate ligands.
cis (optically active)
trans (optically inactive)
d-form
l-form

(* Geometrical isomerism is not shown by tetrahedral complexes.)

Bonding in coordination compounds

- **Valence bond theory :** It was developed by Linus Pauling.
  - A suitable number of vacant orbitals must be present in the central metal atom or ion for the formation of coordinate bonds with the ligands.
  - Central metal ion can use appropriate number of *s*, *p* or *d*-orbitals for hybridisation depending upon the total number of ligands.
  - The outer orbital (high spin) or inner orbital (low spin) complexes are formed depending upon whether outer *d*-orbitals or inner *d*-orbitals are used.

C. No	Type of hybridisation	Geometry	Examples
2	*sp*	Linear	$[Ag(NH_3)_2]^+$, $[Ag(CN)_2]^-$
3	sp^2	Trigonal planar	$[HgI_3]^-$
4	sp^3	Tetrahedral	$Ni(CO)_4$, $[NiX_4]^{2-}$, $[ZnCl_4]^{2-}$, $[CuX_4]^{2-}$, where, $X = Cl^-, Br^-, I^-$
	dsp^2	Square planar	$[Ni(CN)_4]^{2-}$, $[Cu(NH_3)_4]^{2+}$, $[Ni(NH_3)_4]^{2+}$
5	dsp^3	Trigonal bipyramidal	$[Fe(CO)_5]$, $[CuCl_5]^{3-}$
	sp^3d	Square pyramidal	$[SbF_5]^{2-}$
6	d^2sp^3	Octahedral (Inner orbital)	$[Cr(NH_3)_6]^{3+}$, $[Fe(CN)_6]^{3-}$
	sp^3d^2	Octahedral (Outer orbital)	$[FeF_6]^{3-}$, $[Fe(H_2O)_6]^{2+}$, $[Ni(NH_3)_6]^{2+}$

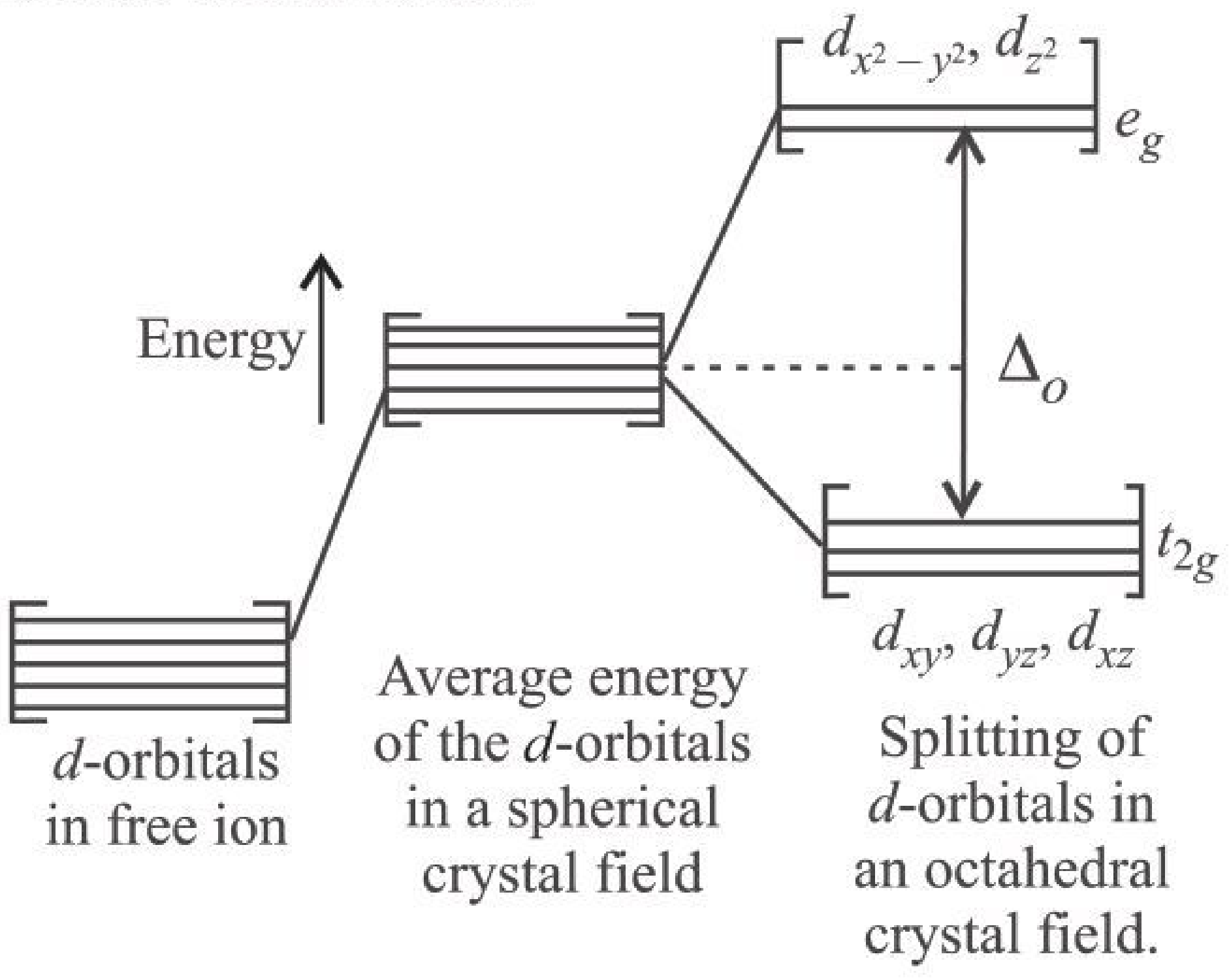
Two different types of coordination complexes on the basis of VBT are discussed as follows :

Inner orbital complexes	Outer orbital complexes
Involves inner *d*-orbitals *i.e.*, $(n-1)d$-orbitals.	Involves outer *d*-orbitals *i.e.*, nd-orbitals.
Low spin complexes	High spin complexes
Have less or no unpaired electrons. *e.g.*, $[Co(NH_3)_6]^{3+}$, $[Co(CN)_6]^{4-}$	Have large number of unpaired electrons. *e.g.*, $[MnF_6]^{3-}$, $[CoF_6]^{3-}$

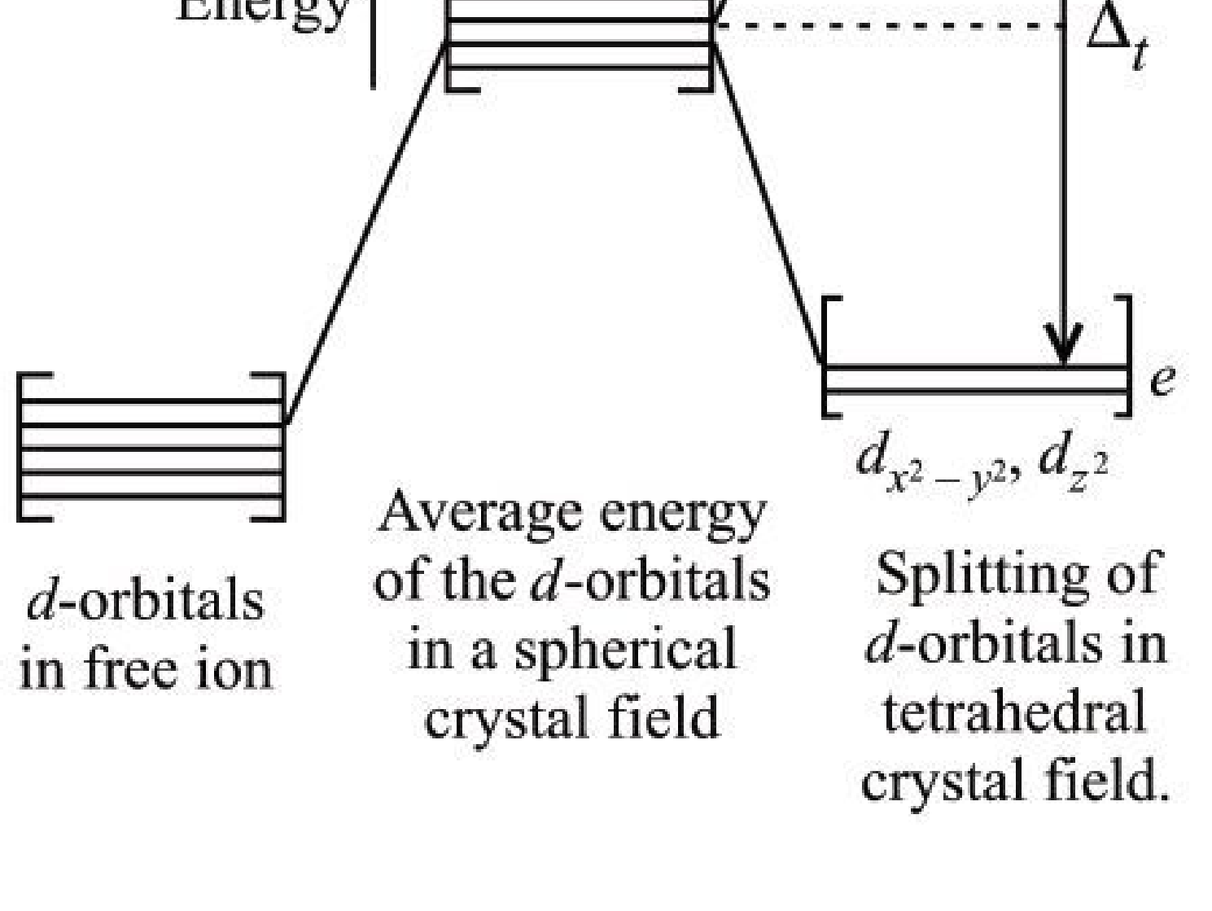
- Low spin complexes are generally diamagnetic and high spin complexes are paramagnetic.
- Paramagnetism ∝ No. of unpaired electrons.
- Magnetic moment $= \sqrt{n(n+2)}$ B.M. where n = number of unpaired electrons.

Crystal Field Theory

- It assumes the ligands to be point charges and there is electrostatic force of attraction between ligands and metal atom or ion. When ligands approach the central metal ion, then the five degenerate orbitals do not possess equal energy any more and results in splitting, which depends upon nature of ligand field strength.
- Greater the ease with which the ligand can approach the metal ion, the greater will be the crystal field splitting caused by it.
- Crystal field splitting in octahedral coordination complexes is shown as :


$d_{x^2-y^2}, d_{z^2}$
e_g
Energy
Δ_o
t_{2g}
d_{xy}, d_{yz}, d_{xz}
d-orbitals in free ion
Average energy of the *d*-orbitals in a spherical crystal field
Splitting of *d*-orbitals in an octahedral crystal field.

- If $\Delta_o < P$ (where 'P' is energy required for forced pairing of electrons) then the electrons will remain unpaired and a high spin complex is formed.
- If $\Delta_o > P$, then pairing of electrons takes place and a low spin complex is formed.
  - Crystal field splitting in tetrahedral complexes is shown as :


d_{xy}, d_{yz}, d_{xz}
t_2
Energy
Δ_t
e
$d_{x^2-y^2}, d_{z^2}$
d-orbitals in free ion
Average energy of the *d*-orbitals in a spherical crystal field
Splitting of *d*-orbitals in tetrahedral crystal field.

- Difference in energy between e and t_2 level is less in tetrahedral complexes.

$$\Delta_t = \frac{4}{9}\Delta_o$$

- **Spectrochemical series :** Arrangement of ligands in the order of increasing field strength.

Weak field ligands $\xrightarrow{\text{Increasing order of CFSE } (\Delta_o)}$ Strong field ligands

$I^- < Br^- < SCN^- < Cl^- < S^{2-} < F^- < OH^- < C_2O_4^{2-} < H_2O < NCS^- < edta^{4-} < NH_3 < en < NO_2^- < CN^- < CO$

COLOUR OF COORDINATION COMPOUNDS

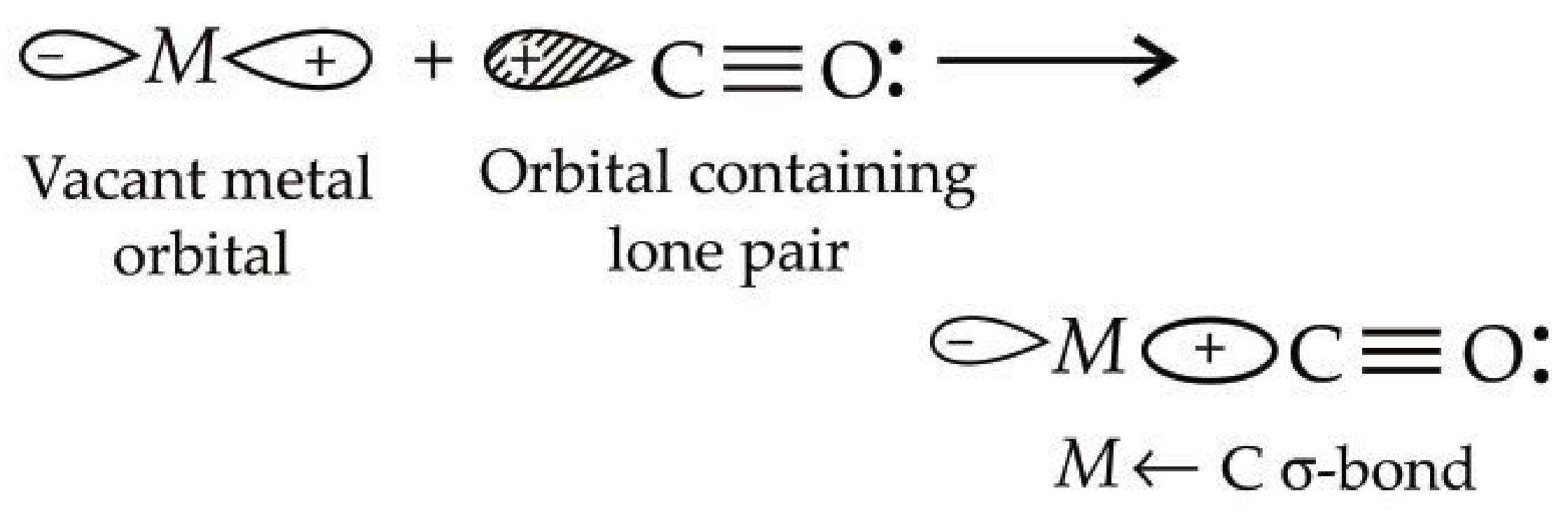
The magnitude of CFSE (Δ_o) for most of the complexes is of the same order as the energy of a photon of visible light. Hence, whenever *d-d* transition takes place, it imparts colour to the complex. The colour of the complex is the colour complementary to the wavelength corresponding to colour absorbed.

For example :

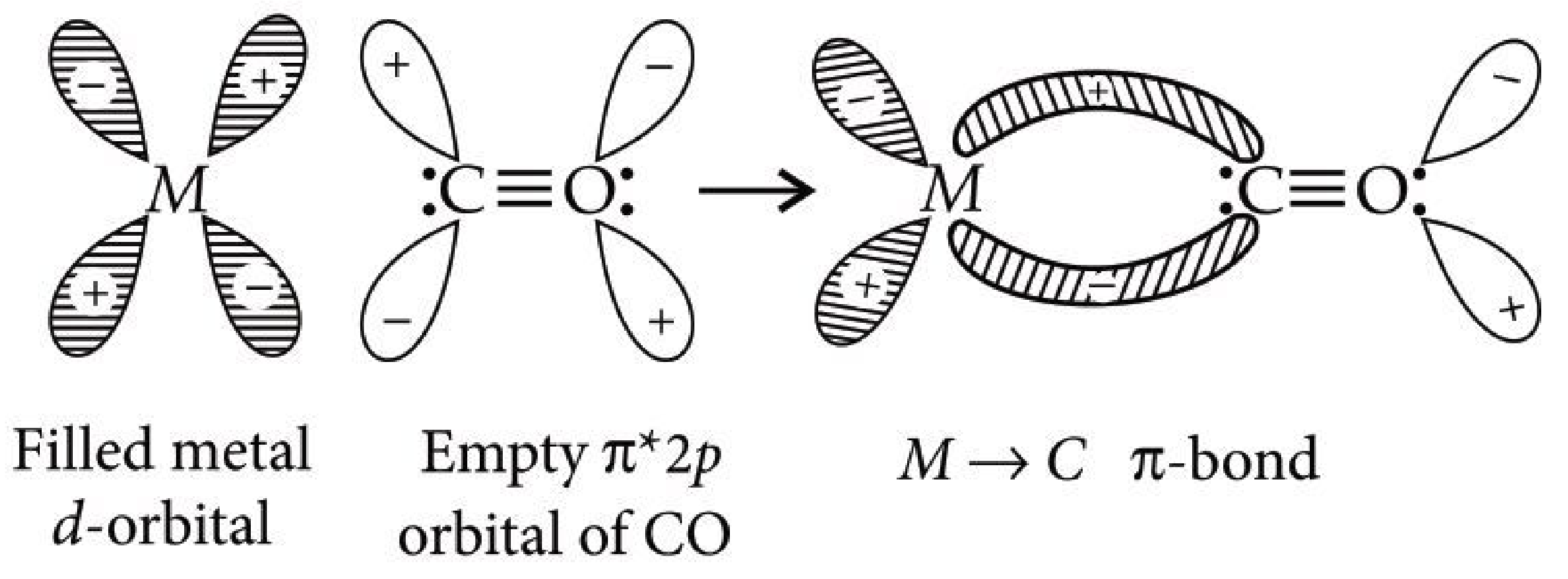
- Hydrated Cu^{2+} ion, *i.e.* $[Cu(H_2O)_4SO_4.H_2O]$ or $CuSO_4.5H_2O$ absorbs yellow radiation and transmits radiation of wavelength corresponding to blue colour and hence looks blue to our eyes.

BONDING IN METAL CARBONYLS

- Metal–carbon bond in metal carbonyls possesses both σ- and π-characters.
- Its formation involves the following steps :
  - Overlap of filled π_{2p} orbital of CO with suitable empty metal *d*-orbital resulting in the formation of sigma bond.


M
+
C≡O:
Vacant metal orbital
Orbital containing lone pair
M
C≡O:
$M \leftarrow C$ σ-bond

  - π-overlap involving filled metal *d*-orbital with an empty antibonding π^*2p orbital of same CO. This results in formation of $M \rightarrow C$ π-bond. This is also called *back bonding.*



STABILITY OF COMPLEXES

- The formation of the complex in a solution is a reversible and exothermic process.

  $Cu^{2+} + 4NH_3 \rightleftharpoons [Cu(NH_3)_4]^{2+}$

  $$K = \frac{[Cu(NH_3)_4]^{2+}}{[Cu^{2+}][NH_3]^4}$$

  where, K = stability constant
- Higher the value of stability constant (K), higher will be the stability of complex.
- Higher the polarising power of metal ion and basicity of ligand, higher will be the stability of complex.

APPLICATIONS OF COORDINATION COMPOUNDS

- Coordination compounds are of great importance in biological system. *e.g.*, chlorophyll, haemoglobin, vitamin B_{12}, etc. are coordinate compounds of Mg, Fe and Co respectively.
- Coordination compounds are used for qualitative and quantitative analysis, extraction of metals, electroplating, photography and as dyes.
- *cis*-platin is used in cancer treatment, EDTA is often used for treatment of lead poisoning.
- Coordination compounds are used as catalysts.

WRAP it up!

MCQs TYPE QUESTIONS

1. The effective atomic number of Cr (Z = 24) in $[Cr(NH_3)_6]Cl_3$ is
   (a) 35 (b) 27 (c) 33 (d) 36

2. When $AgNO_3$ is added to a solution of $Co(NH_3)_5Cl_3$, the precipitate of AgCl shows two ionizable chloride ions. This means
   (a) two chlorine atoms satisfy primary valency and one chlorine atom satisfies a secondary valency
   (b) one chlorine atom satisfies primary as well as secondary valency
   (c) three chlorine atoms satisfy primary valencies
   (d) three chlorine atoms satisfy secondary valencies.

3. Consider the complex $[Co(NH_3)_5CO_3]ClO_4$, the coordination number, oxidation number, number of *d*-electrons and number of unpaired *d*-electrons on the metal ion are, respectively
   (a) 6, 3, 6, 0 (b) 7, 2, 7, 1
   (c) 7, 1, 6, 4 (d) 6, 2, 7, 3

4. Which of the following is not considered as an organometallic compound?
   (a) *cis*-platin (b) Ferrocene
   (c) Zeise's salt (d) Grignard reagent

5. Which of the following descriptions is incorrect?
   (a) $[Ni(NH_3)_4]^{2+}$: Square Planar, diamagnetic
   (b) $[Ni(CN)_4]^{2-}$: Square planar, diamagnetic
   (c) $[Ni(CO)_4]$: Tetrahedral, diamagnetic
   (d) $[NiCl_4]^{2-}$: Tetrahedral, paramagnetic.

6. Out of the following complexes, which one show outer orbital hybridisation?
   (a) $[Zn(NH_3)_6]^{2+}$ (b) $[Co(NH_3)_6]^{3+}$
   (c) $[Cr(NH_3)_6]^{3+}$ (d) $[V(NH_3)_6]^{3+}$

7. In $[Co(NH_3)_6]Cl_3$, the number of covalent bonds is
   (a) 3 (b) 6 (c) 9 (d) 18

8. Diethylenetriamine is
   (a) chelating agent (b) neutral ligand
   (c) tridentate ligand (d) all of these.

9. The IUPAC name for $K_2[Cr(CN)_2O_2(O_2)NH_3]$ is
   (a) potassium amminedicyanidodioxidoperoxidochromate(VI)
   (b) potassium amminedicyanidotetroxidochromium (III)
   (c) potassium amminedicyanidochromate(IV)
   (d) potassium amminocyanidodiperoxidochromate (VI).

10. The compound which does not show paramagnetism is
    (a) $[Cu(NH_3)_4]Cl_2$ (b) $[Ag(NH_3)_2]Cl$
    (c) NO (d) NO_2

11. Which of the following is a chelating agent?
(a) Thiosulphato (b) Oxalato
(c) Hydrazinium ion (d) Phosphine

12. The colour of the coordination compounds depends on the crystal field splitting. What will be the correct order of absorption of wavelength of light in the visible region, for the complexes, $[Co(NH_3)_6]^{3+}$, $[Co(CN)_6]^{3-}$, $[Co(H_2O)_6]^{3+}$?
(a) $[Co(CN)_6]^{3-} > [Co(NH_3)_6]^{3+} > [Co(H_2O)_6]^{3+}$
(b) $[Co(NH_3)_6]^{3+} > [Co(H_2O)_6]^{3+} > [Co(CN)_6]^{3-}$
(c) $[Co(H_2O)_6]^{3+} > [Co(NH_3)_6]^{3+} > [Co(CN)_6]^{3-}$
(d) $[Co(NH_3)_6]^{3+} > [Co(CN)_6]^{3-} > [Co(H_2O)_6]^{3+}$

13. $[Co(en)_2(NO_2)_2]Cl$ exhibits
(a) linkage isomerism, geometrical isomerism and optical isomerism
(b) linkage isomerism, ionization isomerism and optical isomerism
(c) linkage isomerism, ionization isomerism and geometrical isomerism
(d) ionization isomerism, geometrical isomerism and optical isomerism.

14. The IUPAC name of $Na[PCl_6]$ is
(a) sodium hexachlorophosphine(V)
(b) sodium hexachlorophosphate(V)
(c) sodium hexachlorophosphine
(d) sodium hexachlorophosphite(V)

15. Amongst the following, the most stable complex is
(a) $[Fe(H_2O)_6]^{3+}$ (b) $[Fe(NH_3)_6]^{3+}$
(c) $[Fe(C_2O_4)_3]^{3-}$ (d) $[FeCl_6]^{3-}$

16. Low spin complex of d^6-cation in an octahedral field will have the following energy (Δ_o = crystal field splitting energy in an octahedral field, P = Electron pairing energy)
(a) $\frac{-12}{5}\Delta_o + P$ (b) $\frac{-12}{5}\Delta_o + 3P$
(c) $\frac{-2}{5}\Delta_o + 2P$ (d) $\frac{-2}{5}\Delta_o + P$

17. Homoleptic octahedral complexes of a metal ion M^{3+} with three monodentate ligands L_1, L_2 and L_3 absorb wavelengths in the region of green, blue and red respectively. The increasing order of the ligand strength is
(a) $L_3 < L_1 < L_2$ (b) $L_1 < L_2 < L_3$
(c) $L_2 < L_1 < L_3$ (d) $L_3 < L_2 < L_1$

18. Transition metal complex with highest value of crystal field splitting (Δ_o) will be
(a) $[Cr(H_2O)_6]^{3+}$ (b) $[Mo(H_2O)_6]^{3+}$
(c) $[Fe(H_2O)_6]^{3+}$ (d) $[Os(H_2O)_6]^{3+}$

19. Pick out the wrong combination.
(a) Co^{2+} - Vitamin B_{12} (b) Se^{2+} - Kreb's cycle
(c) Mg^{2+} - Photosynthesis
(d) Fe^{2+} - Haemoglobin

20. The geometry of $[Ni(CO)_4]$ and $[Ni(PPh_3)_2Cl_2]$ are
(a) both square planar
(b) tetrahedral and square planar
(c) both tetrahedral
(d) square planar and tetrahedral.

NUMERICAL VALUE TYPE QUESTIONS

21. For a complex, $[Fe(CN)_6]^{4-}$ having $\Delta_o = 32800\ cm^{-1}$ and $P = 17{,}600\ cm^{-1}$, the CFSE is $-x$. What is the value of x?

22. The complex $[Pt(py)(NH_3)BrCl]$ will have _______ geometrical isomers.

23. $[Fe(CN)_6]^{3-}$ should be an inner orbital complex. Ignoring the pairing energy, the value of crystal field stabilisation energy for this complex is (–) _______ Δ_o. (Nearest integer)

24. $[Ti(H_2O)_6]^{3+}$ absorbs light of wavelength 498 nm during a d-d transition. The octahedral splitting energy for the above complex is _______ $\times 10^{-19}$ J. (Round off to the Nearest Integer).
$h = 6.626 \times 10^{-34}$ Js; $c = 3 \times 10^8\ ms^{-1}$.

25. The volume (in mL) of 0.125 M $AgNO_3$ required to quantitatively precipitate chloride ions in 0.3 g of $[Co(NH_3)_6]Cl_3$ is _______.
$M_{[Co(NH_3)_6]Cl_3} = 267.46$ g/mol
$M_{AgNO_3} = 169.87$ g/mol

SOLUTIONS

1. **(c) :** Oxidation state of Cr in $[Cr(NH_3)_6]Cl_3 = +3$
EAN = Electrons on Cr^{3+} + Electrons from $6NH_3$ molecules = 21 + 12 = 33

2. **(a) :** Only primary valencies are ionizable. Presence of two ionizable chloride ions shows that two chlorine atoms satisfy primary valency and remaining one chlorine atom satisfies secondary valency.

3. **(a)**

4. **(a) :** *cis*-platin, *cis*-$[PtCl_2(NH_3)_2]$ does not contain any metal - carbon bond, hence it is not an organometallic compound.

5. **(a)**

6. **(a) :** Oxidation number of Zn in $[Zn(NH_3)_6]^{2+} = +2$
$Zn^{2+} \longrightarrow 3d^{10}$
Inner d-orbital, $(n-1)d$ is completely filled. So outer d-orbital takes part in hybridisation giving sp^3d^2 hybridisation.

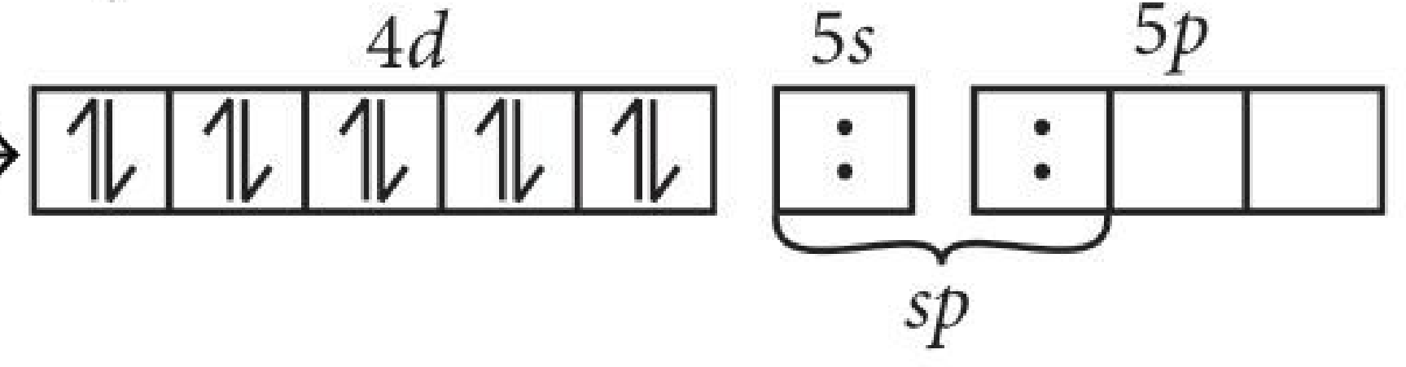
7. (d) : $M - L$ bond is coordinate. In ligand itself, NH_3, three hydrogens are covalently linked to nitrogen atoms. Hence, total number of covalent bonds $= 6 \times 3 = 18$

8. (d)

9. (a) : $K_2[Cr(CN)_2O_2(O_2)NH_3]$:
Potassium amminedicyanidodioxidoperoxidochromate(VI)

10. (b) : In $[Ag(NH_3)_2]Cl$, oxidation state of Ag = +1
$Ag^+ \longrightarrow 4d^{10}$
Ag will undergo *sp*-hybridisation.

$[Ag(NH_3)_2]Cl \longrightarrow$



Since all electrons are paired, it does not show paramagnetism.

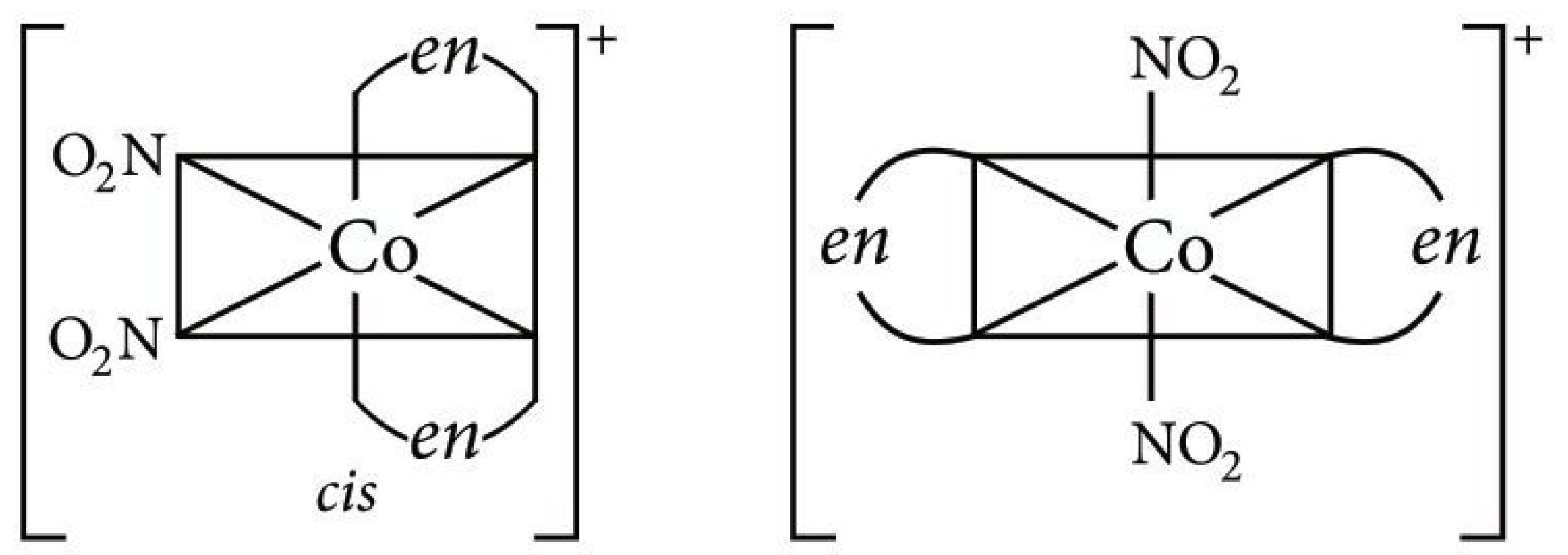
11. (b) : Oxalato is a chelating agent since it is a bidentate ligand.

12. (c) : As strength of ligand increases, crystal field splitting energy increases.

Now, $\Delta E = \dfrac{hc}{\lambda}$

So, as *CFSE* increases, ΔE increases and λ decreases.
$[Co(H_2O)_6]^{3+} > [Co(NH_3)_6]^{3+} > [Co(CN)_6]^{3-}$

13. (c) : Ionization isomerism arises when the coordination compounds give different ions in solution.
$[Co(en)_2(NO_2)]Cl \rightleftharpoons [Co(en)_2(NO_2)_2]^+ + Cl^-$
Linkage isomerism occurs in complex compounds which contain ambidentate ligands like NO_2^-, SCN^-, CN^-, $S_2O_3^{2-}$ and CO.
$[Co(en)_2(NO_2)_2]Cl$ and $[Co(en)_2(ONO)_2]Cl$
are linkage isomers as NO_2^- is linked through N or through O.
Octahedral complexes of the type Ma_4b_2 exhibit geometrical isomerism.



14. (b)

15. (c) : Since $C_2O_4^{2-}$ is a bidentate ligand, it forms the most stable complex because of chelation.

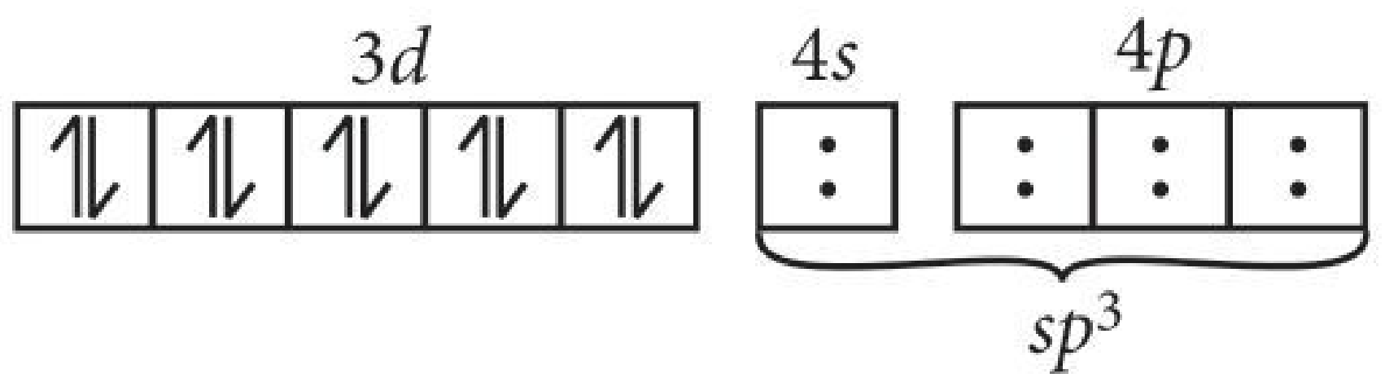
16. (b) : C.F.S.E. $= (-0.4x + 0.6y)\Delta_o + zP$
where, x = number of electrons occupying t_{2g} orbital
y = number of electrons occupying e_g orbital
z = number of pairs of electrons
For low spin d^6 complex, electronic configuration
$= t_{2g}^6 e_g^0$ or $t_{2g}^{2,2,2} e_g^0$
$\therefore \quad x = 6, y = 0, z = 3$
C.F.S.E. $= (-0.4 \times 6 + 0 \times 0.6)\Delta_o + 3P$
$= \dfrac{-12}{5}\Delta_o + 3P$

17. (a) **18. (d)**

19. (b) : Kreb's cycle takes place in mitochondria of cell which does not involve Se^{2+} ion.

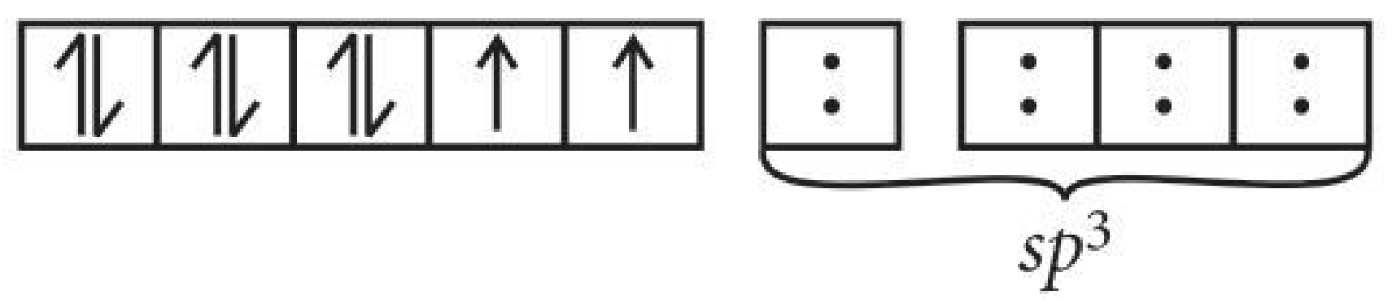
20. (c) : Oxidation state of Ni in $[Ni(CO)_4]$ is zero.
Ni^0 $(Z = 28) = 3d^8\,4s^2$
Since CO is a strong field ligand, it forces electrons to pair up and thus sp^3 hybridisation takes place which results in tetrahedral geometry.

$[Ni(CO)_4] \longrightarrow$

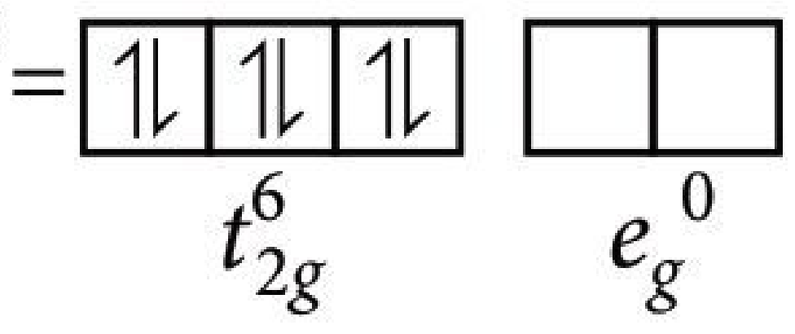


In $[Ni(PPh_3)_2Cl_2]$, oxidation state of Ni = +2
Since both PPh_3 and Cl^- are weak field ligand, they do not force electrons to pair up and thus sp^3 hybridisation takes place which result in tetrahedral geometry.

$[Ni(PPh_3)_2Cl_2] \longrightarrow$

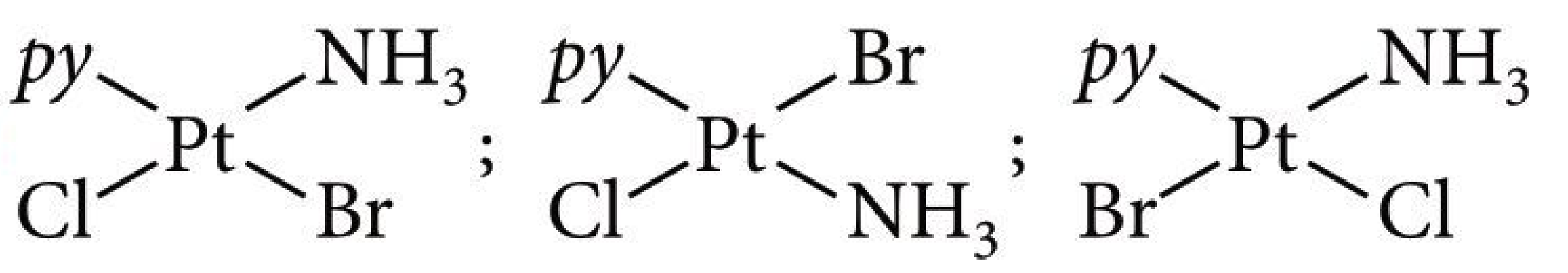


21. (25920) : For $[Fe(CN)_6]^{4-}$: Fe^{2+} : $d^6 =$



CFSE $= (-0.4x + 0.6y)\Delta_o + 3P$
$= (-0.4 \times 6 + 0.6 \times 0)\,\Delta_o + 3P$
$= (-2.4 \times 32800) + (3 \times 17600) = -78720 + 52,800$
$x = -25920\ \text{cm}^{-1} \quad \therefore \quad x = 25920$

22. (3) :



The complex is square planar and is of the type $[M(abcd)]$. So, it has three isomers.

23. (2) : Fe^{3+} ion configuration : $[Ar]3d^5$
Fe^{3+} in $[Fe(CN)_6]^{3-}$: $t_{2g}^5\,e_g^0$
CFSE $= 5 \times (-0.4)\Delta_o = -2\Delta_o$

24. (4) : $\Delta_o = E = \dfrac{hc}{\lambda_{\text{abs.}}} = \dfrac{6.626 \times 10^{-34} \times 3 \times 10^8}{498 \times 10^{-9}}$
$= 4 \times 10^{-19}$ J

25. (26.92)

Be Lab READY!

Class XII

Experiment-1

AIM

- To determine the enthalpy of neutralisation of strong acid (HCl) and strong base (NaOH).

THEORY

- Heat is evolved during neutralisation of an acid with an alkali. Known volumes of the standard solutions of an acid and alkali are mixed and the change in temperature is observed and from this, the enthalpy of neutralisation is calculated. Enthalpy of neutralisation is the heat evolved when one gram equivalent of the acid is completely neutralised by a base in dilute solution.
- This is because strong acids and strong bases are completely ionised in aqueous solutions. For example, in the reaction between hydrochloric acid and sodium hydroxide ion, the neutralization can be represented as

$$HCl_{(aq)} + NaOH_{(aq)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)} + Na^+_{(aq)} + OH^-_{(aq)}$$
$$\rightarrow NaOH_{(aq)} + H_2O_{(l)};\ \Delta H = -57.3 \text{ kJ/mol}$$

  The heat of neutralization of a weak acid or a weak base is less than – 57.3 kJ/mol.

REQUIREMENTS

- **Apparatus :** Two beakers (250 mL), thermometer, stirrer, wooden box, measuring cylinder, wire gauze and burner.
- **Chemicals :** 0.2 M HCl (100 mL), 0.2 M NaOH solution (100 mL) and distilled water.

PROCEDURE

- **For the determination of water equivalent**
  1. Take 100 mL distilled water in a beaker and put it in thermally insulated wooden box in which thermometer and stirrer are inserted.
  2. Note down the temperature of water (t_1°C).
  3. Take 100 mL distil water in another beaker. Warm it upto 40°–50°C higher than that of room temperature. Now note down the temperature (t_2°C).
  4. Now pour this warm water into the beaker kept in wooden box immediately.
  5. Stir the contents and note down the temperature after mixing (t_3°C).
- **For the determination of heat of neutralization**
  1. Take 100 mL of 0.2 M HCl in the beaker, whose water equivalent has been determined previously and keep it in a thermally insulated wooden box. Note down its temperature (t_4°C).
  2. Take 100 mL of 0.2 M NaOH solution in another beaker and note down its temperature. (Both solutions should have same temperature otherwise wait for them to attain same temperature.)
  3. Add NaOH solution in the beaker containing HCl.
  4. Stir the mixture and note down the temperature (t_5°C).

OBSERVATIONS

Volume of cold water = 100 mL ≈ 100 g
Initial temp. of cold water = t_1°C
Volume of hot water = 100 mL ≈ 100 g
Temperature of hot water = t_2°C
Temperature of mixture = t_3 °C
Volume of HCl taken = Volume of NaOH taken
= 100 mL ≈ 100 g
Temperature of HCl = Temp. of NaOH = t_4°C
Temperature of HCl + temp. of NaOH = t_5 °C

CALCULATIONS

(A) For determining water equivalent

Increase in temperature of cold water = $(t_3 - t_1)$°C
Decrease in temperature of hot water = $(t_2 - t_3)$°C

Now, heat gained by cold water + heat gained by the beaker = heat lost by the hot water (according to principle of calorimetry)

Heat gained or lost by a substance
= mass × specific heat × rise or fall in temperature.

Therefore, $100 \times 4.2 \times (t_3 - t_1) + W \times (t_3 - t_1)$
$= 100 \times 4.2 \times (t_2 - t_3)$

∵ Specific heat of water = 4.2 J/g/°C

and W = mass of beaker × specific heat of the beaker
= Water equivalent of the beaker

Now, $(t_3 - t_1)\,[(100 \times 4.2) + W] = 100 \times 4.2 \times (t_2 - t_3)$

$$(100\times4.2)+W=\frac{100\times4.2(t_2-t_3)}{(t_3-t_1)}$$

$$W=\left(\frac{100\times4.2(t_2-t_3)}{(t_3-t_1)}\right)-(100\times4.2)\ \text{J}/{}^\circ\text{C}$$

(B) For determinating heat of neutralization

Increase in temperature of acid or base after mixing the two solutions = $(t_5 - t_4)$°C

∵ Heat evolved during neutralization of 100 mL of 0.2 M HCl = $(200 + W) \times (t_5 - t_4) \times 4.2$ Joule

∴ Heat evolved during neutralization of 1000 mL of

$$1\text{ M HCl}=\frac{(200+W)\times(t_5-t_4)\times4.2}{0.2}\times\frac{1000}{100}\text{ J}$$

∴ Enthalpy of neutralization

$$=\frac{(200+W)\times(t_5-t_4)\times4.2}{0.2\times100}\text{ kJ}$$

RESULTS

The enthalpy of neutralization of HCl with NaOH is ____kJ.

Percentage error = ____

Viva-Voce

1. Why is the enthalpy of neutralization of a strong acid with a strong base always the same?
2. Is the enthalpy of neutralization of acetic acid the same as that of HCl? If not, why?
3. What is the value of enthalpy of neutralization of a strong acid and a strong base?
4. What is the principle of determining heat of neutralization?
5. Which is most expected error in determining heat of neutralisation?

Solutions

1. This is because it always involves the combination of one mole of H^+ ions with OH^- ions to form unionised water molecules.
2. Acetic acid is a weak acid and is not completely ionised. Some heat is used up the ionisation of acetic acid. Hence, the net heat evolved is less and not the same as that of HCl which is completely ionised.
3. When one gram equivalent of a strong acid is neutralised by one mole of a strong base or *vice-versa*, the enthalpy change is always equal to –57.3 kJ.
4. The principle of determining the heat of neutralization is heat balance relation, *i.e.*

   Heat gained = Heat lost
5. Temperature recording.

Experiment-2

AIM

- To prepare a pure sample of ferrous ammonium sulphate (Mohr's salt).

THEORY

- Mohr's salt, *i.e.*, ferrous ammonium sulphate $[FeSO_4.(NH_4)_2SO_4.6H_2O]$ is a double salt. It can be prepared by making equimolar solutions of hydrated ferrous sulphate and ammonium sulphate in minimum quantity of water. Little amount of dil. H_2SO_4 is added to prevent hydrolysis of $FeSO_4.7H_2O$. Cooling of the hot saturated solution yields bluish green crystals of Mohr's salt.

$$\underset{278\text{ g mol}^{-1}}{FeSO_4.7H_2O} + \underset{132\text{ g mol}^{-1}}{(NH_4)_2SO_4} \longrightarrow \underset{392\text{ g mol}^{-1}}{FeSO_4.(NH_4)_2SO_4.6H_2O} + H_2O$$

REQUIREMENTS

- **Apparatus :** Two beakers (250 mL), china-dish, funnel, funnel stand, glass rod, wash bottle, tripod stand and wire gauze.
- **Chemicals :** Ferrous sulphate crystals, ammonium sulphate crystals, dilute sulphuric acid and ethyl alcohol.

PROCEDURE

1. Take a 250 mL beaker and wash it with water. Transfer 7.0 g ferrous sulphate and 3.5 g ammonium sulphate crystals to it. Add about 2-3 mL of dilute sulphuric acid to prevent the hydrolysis of ferrous sulphate.
2. In another beaker, boil about 20 mL of water for about 5 minutes to expel dissolved air.
3. Add the boiling hot water to the contents in the first beaker in small installments at a time. Stir with a glass rod until the salts have completely dissolved.
4. Filter the solution to remove undissolved impurities and transfer the filtrate to a china-dish.
5. Heat the solution in the china-dish for some time to concentrate it to the crystallisation point.
6. Place the china-dish containing saturated solution over a beaker full of cold water. On cooling, crystals of Mohr's salt separate out.
7. Decant off the mother liquor quickly. Wash the crystals in the china-dish with a small quantity of alcohol to remove any sulphuric acid sticking to the crystals.
8. Dry the crystals by placing them between filter paper pads.

RESULTS

1. Yield of crystals = _______ g
2. Colour of crystals = _______
3. Shape of crystals = _______

Viva-Voce

1. Why is crystallisation done?
2. Why is dilute H_2SO_4 added during the preparation of Mohr's salt crystals?
3. What is mother liquor?
4. In the preparation of Mohr's salt, can concentrated H_2SO_4 be used in place of dilute H_2SO_4?
5. Why is water used for the preparation of Mohr's salt solution, boiled for 5 minutes?

Solutions

1. Crystal is the purest form of a substance with well defined geometry. Crystallisation is done to get a substance in its purest form.
2. To prevent the hydrolysis of ferrous sulphate.
3. The liquid left behind after the separation of crystals from the saturated solution is called mother liquor.
4. No, because it would oxidize ferrous ions to ferric ions.
5. It is done in order to expel dissolved oxygen from the water which otherwise would oxidize ferrous salt to ferric salt.

Experiment-3

AIM

- To separate the coloured components present in the mixture of red and blue inks by ascending paper chromatography and find their R_f values.

THEORY

- The basic principle of chromatographic technique is based on the differential migration of the individual components of a mixture through a stationary phase under the influence of moving phase. The stationary phase may be a porous solid (such as silica, alumina, etc.) packed in a column or supported on a filter paper or a glass strip. The moving (or mobile) phase may be some solvent or a gas and is referred as an eluent.
- **Paper Chromatography :** It is mainly a type of partition chromatography in which a special adsorbent paper is used instead of a column. Moisture adsorbed by this acts as a stationary phase and the solvent as a moving phase. The mixture to be separated or analysed is put at one end of the paper strip as a small spot. The paper is placed in a container, with a suitable solvent, vertically in such a way that the lower end (where the mixture spot is

put) dips in the solvent and the spot remains slightly above the solvent level as shown in the figure below.

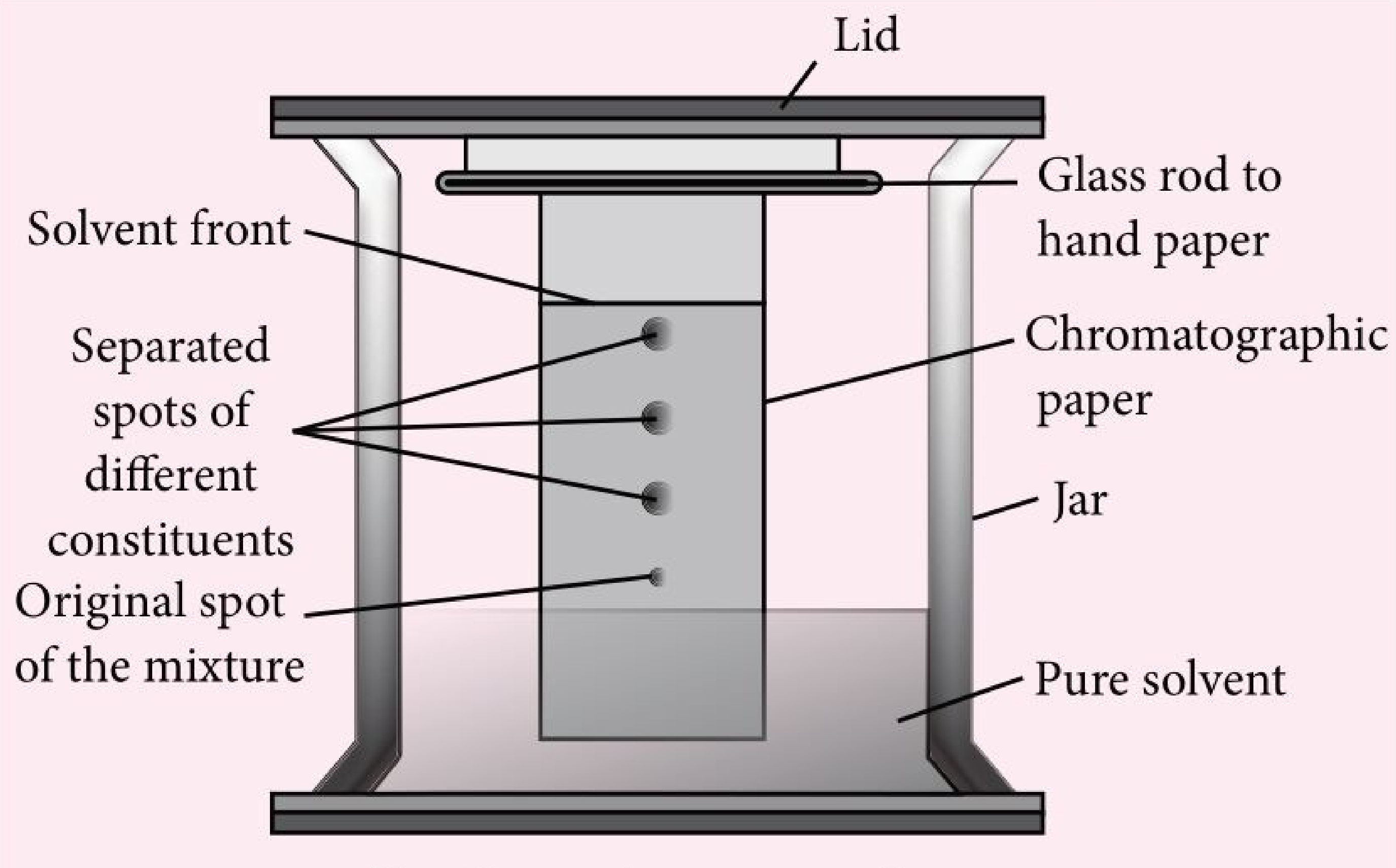


Fig.: Paper chromatography

The solvent rises up the paper due to capillary action and the components of the mixture rise up at different rates and thus get separated from one another as shown in the figure above.

REQUIREMENTS

- **Apparatus :** Gas jar, glass rod, filter paper strip (Whatman filter paper 1), jar cover and fine capillary tube.
- **Chemicals :** A mixture of red and blue inks, alcohol and distilled water.

PROCEDURE

1. Take a Whatman filter paper strip (20 × 2 cm) and draw a line with pencil above 4 cm from one end.
2. With the help of fine capillary tube, put a drop of the mixture of red and blue inks at the point *P i.e.*, centre of the line. Let it dry in air. Put another drop on the same spot and dry again. Repeat it 2-3 times, so that the spot gets loaded with the mixture.
3. Suspend the filter paper vertically in a gas jar containing the solvent (eluent) with the help of a glass rod in such a way that the pencil line (and the spot) remains above the solvent level. Solvent is a mixture of alcohol and water.
4. Cover the jar and keep it undisturbed. The solvent will rise along with the mixture of red and blue inks. After the solvent has risen about 12-15 cm you will observe two different spots of blue and red colour on the filter paper.
5. Take the filter paper out of the jar and mark the distance that the solvent has risen on the paper with a pencil. This is called the solvent front. Measure this using scale.
6. Dry the paper. Put pencil marks in the centre of the blue and red spots.
7. Also measure the distance of the two spots from the original line.
8. Calculate the R_f values of the blue and red inks by using the formula :

$$R_f = \frac{\text{Distance travelled by the blue or red ink from the point of application}}{\text{Distance travelled by the solvent from the original line}}$$

OBSERVATIONS AND CALCULATIONS

Substance	Distance travelled by different components	Distance travelled by solvent	R_f value
Red ink + Blue ink	A cm (Red Ink) B cm (Blue Ink)	X cm Y cm	A/X B/X

Viva-Voce

1. What is the principle of chromatographic process?
2. What type of solvents are generally employed in chromatography?
3. How does the liquid rise through the filter paper?
4. Can we separate colourless substances by chromatography?
5. What are the different types of paper chromatography?

Solutions

1. It is based on the differential migration of the individual components of a mixture through a stationary phase under the influence of a moving phase.
2. Generally, solvents having low viscosities are employed in chromatography. This is due to the fact that the rate of flow of a solvent varies inversely as its viscosity.
3. Capillary action is responsible for the rise of liquid through filter paper.
4. Yes, in case of colourless substances, the components will not be visible on the chromatogram. Their presence can be detected by spraying a suitable reagent on the chromatogram called developer. Developer makes the constituents visible.
5. (i) Ascending paper chromatography
   (ii) Descending paper chromatography
   (iii) Circular/Radical paper chromatography

◆ ◆

WORD GRID

Readers are
requested to send
their responses of
word grid.
Be the Winner!

Find and encircle the words in the given grid, running in one of the possible directions; horizontal, vertical or diagonal by reading the clues given below.

C	R	A	O	P	V	W	X	S	L	I	H	A	J	M	T
X	D	T	J	P	C	N	C	O	W	U	N	D	K	G	V
W	Y	R	Q	Y	V	G	O	Z	N	I	Y	A	X	A	U
C	J	U	C	K	E	Z	N	F	B	L	I	L	E	N	L
A	W	R	O	U	G	H	T	V	S	A	E	T	G	G	C
T	J	N	B	S	L	S	A	S	Q	V	H	E	X	U	A
E	S	Q	A	W	J	I	C	X	L	M	H	A	Q	E	N
N	M	I	L	S	U	F	T	L	I	Y	J	N	H	A	I
A	V	T	T	Q	C	I	L	I	R	X	T	S	O	I	S
T	Y	A	S	J	I	H	A	U	E	S	L	F	H	A	A
I	F	M	C	D	O	C	C	G	L	A	H	A	Z	R	T
O	A	E	K	X	L	R	H	U	H	K	H	A	C	O	I
N	O	O	S	A	E	S	L	S	R	S	H	A	X	S	O
K	V	E	Y	M	L	W	A	I	X	H	J	N	E	O	N

Clues

1. The self-linking ability of atoms of an element to create chains and rings.
2. It is the cell used in low current devices like hearing aids, watches etc.
3. The unwanted earthy materials present in ores of a metal.
4. The purest form of commercial iron prepared from cast iron in a reverberatory for furnace.
5. It is a gas used in discharge tubes and fluorescent bulbs for advertisement display purposes.
6. The process used for the preparation of sulphuric acid.
7. It is the *d*-block element that is present at the centre of the ring of cyanocobalamine (Vitamin B_{12}).
8. The process of heating raw rubber with sulphur to improve its physical properties.

*Please send entries of solutions both with words and scanned copy of the grid by 10th of every month.

Mechanistic Approach to

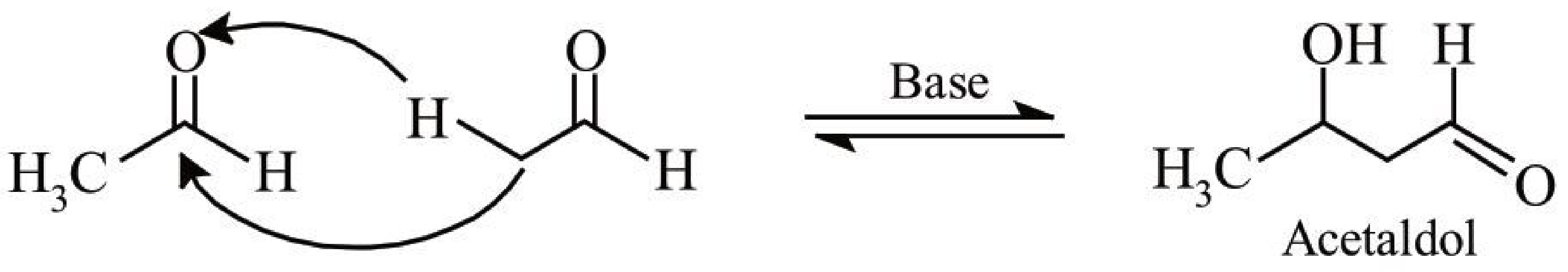
ORGANIC CHEMISTRY

Enhance your concepts of organic reaction mechanisms to score good marks in various competitive exams....

ALDOL CONDENSATION

The addition reaction of enol or enolate to the carbonyl group of aldehydes or ketones is known as aldol (aldehyde + alcohol) addition. Dilute bases such as NaOH, KOH, $Ba(OH)_2$ or NaH are used as reagents. Aldol condensations are also catalysed by acids.

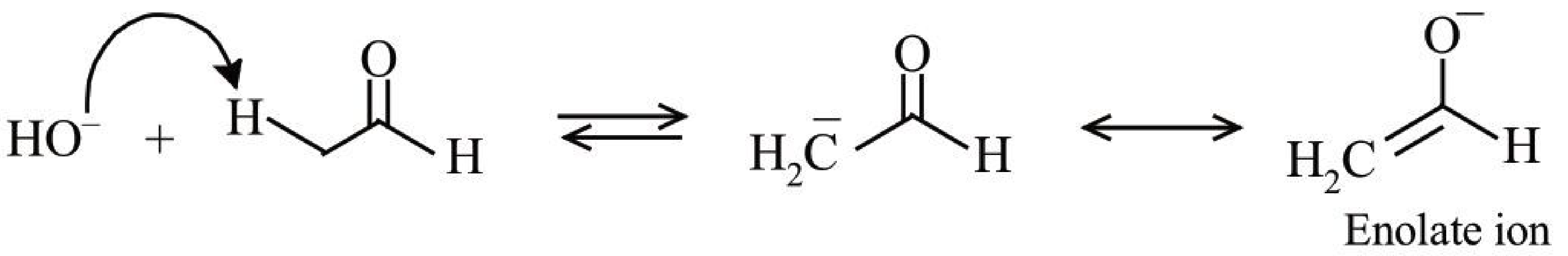
Base catalysed : Aldol condensation between two molecules of same aldehyde or ketones is called simple aldol condensation. Acetaldehyde is the simplest aldehyde to undergo aldol condensation. NaOH is the base.



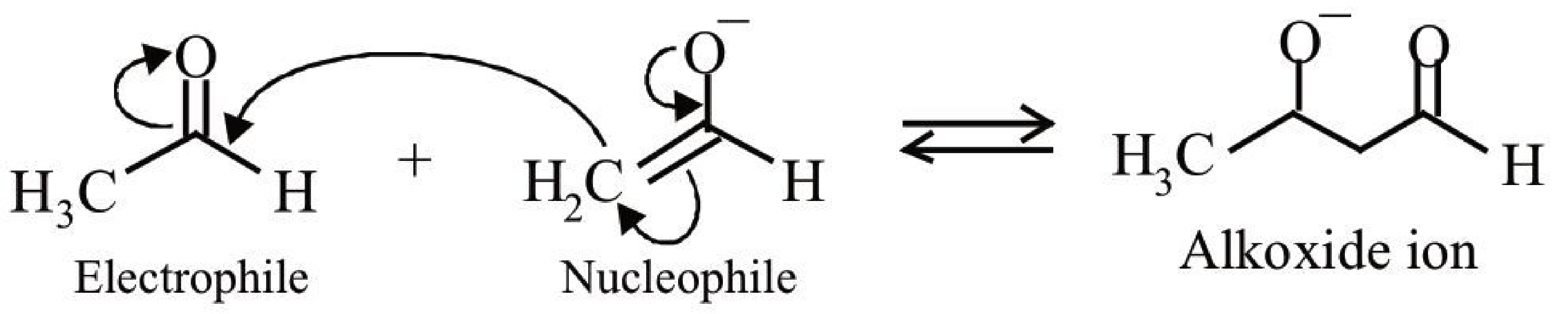
Mechanism

Addition: The acidity of a C – H bond on a carbon directly attached to a carbonyl group is higher by many times of ten as compared to ordinary C – H bond. Removal of such a proton gives enolate ion, an ambident nucleophile.

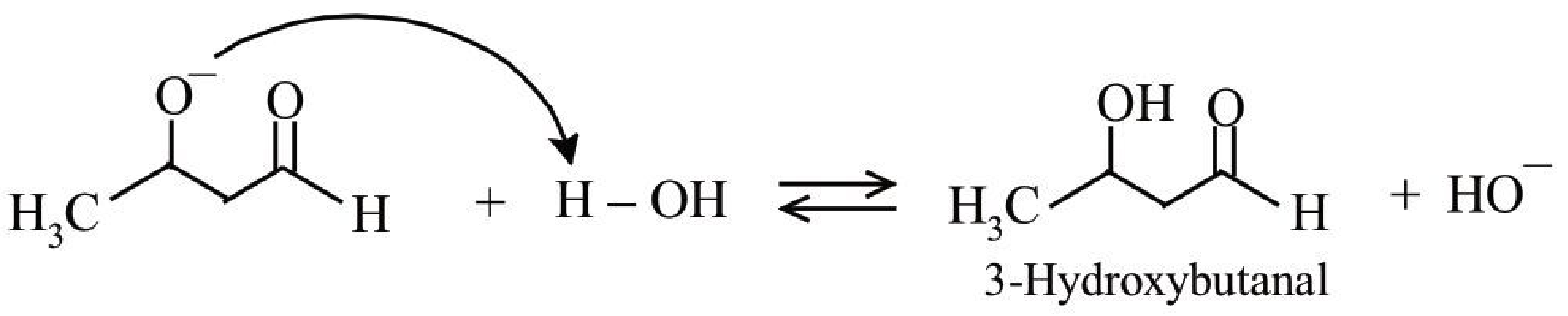
Step I: Deprotonation of α-carbon to give an enolate :



At low concentration of hydroxide, the below step is the rate determining step, means the reaction follows second order kinetics. The ambident nucleophile then attacks *via* its carbon atom to form an alkoxide anion as C—C bond is more stable due to less polarity difference.

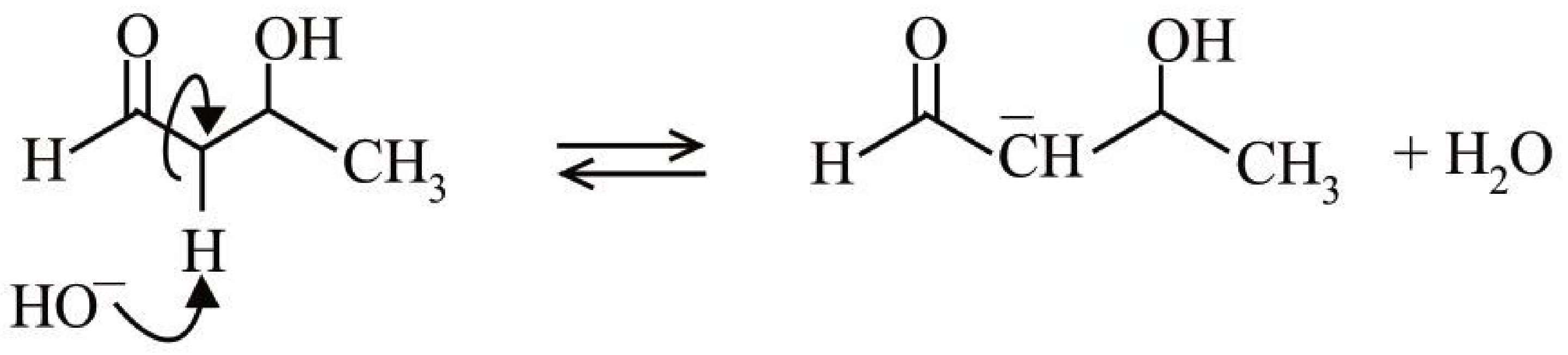


It is interesting to note that at high concentration of hydroxide, the given step is the rate determining step and the reaction is termolecular. In the final step, a stronger base removes a proton from water to regenerate a hydroxide ion, a weaker base.

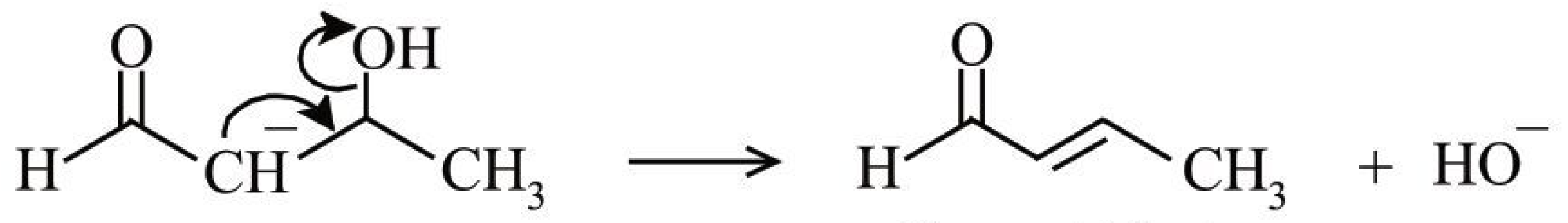


Why the enolate ion, an ambident nucleophile does not attack through its oxygen atom?
Because such reactions are thermodynamically unfavourable, which would have formed a C – O bond instead of a C – C bond.

Dehydration: Heating the aldol addition product with base leads to loss of H_2O giving a new C—C π bond. This can be attributed to two reasons. First, the acidity of the remaining α-hydrogens and second the stability of the conjugated double bonds.



The above step is a fast step. In the next slow step, enolate gives rise to conjugated aldehyde.



Crotonaldehyde

Aldol Reaction of Unsymmetrical Ketones

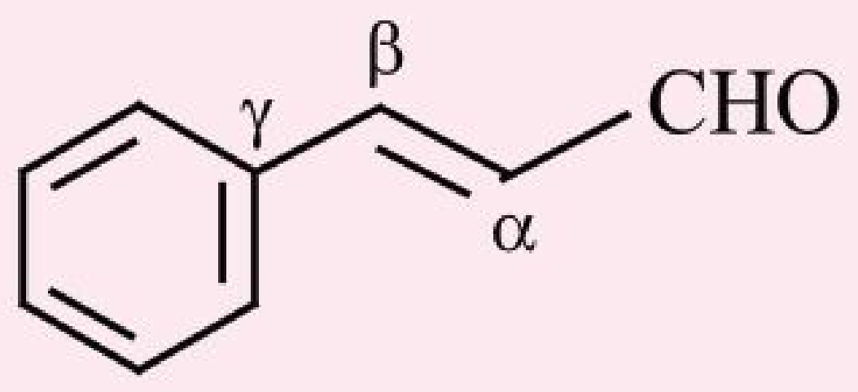
Features:

- Presence of –*I* group accelerates the rate of aldol condensation, whereas +*I* group retards it.
- When an aryl group is present at the β-carbon atom of an aldehyde, dehydrated product is formed almost invariably.
- In presence of strong alkali, repeated aldol condensation may take place to produce high molecular mass resin.
- During aldol condensation little hydrated product is also formed. For example, acetaldehyde gives little amount of $CH_3CH(OH)_2$ during aldol condensation.

Crossed Aldol Condensation

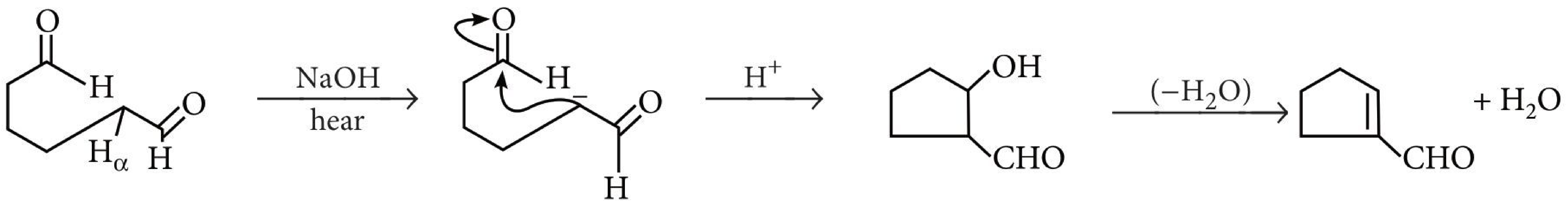
The aldol condensation between two different aldehydes or ketones or between one aldehyde and one ketone is called crossed aldol condensation. Generally with two different aldehydes, four types of products are theoretically possible due to presence of multiple different α-hydrogens. However, by carefully choosing the condition, one product may be made to dominate.

Cinnamaldehyde though contains α-hydrogen but still fails to undergo aldol condensation. Why?
For α,β-unsaturated aldehyde, it is the γ-hydrogen atom which is required for aldol condensation to take place. Cinnamaldehyde does not have γ-hydrogen.



Cinnamaldehyde

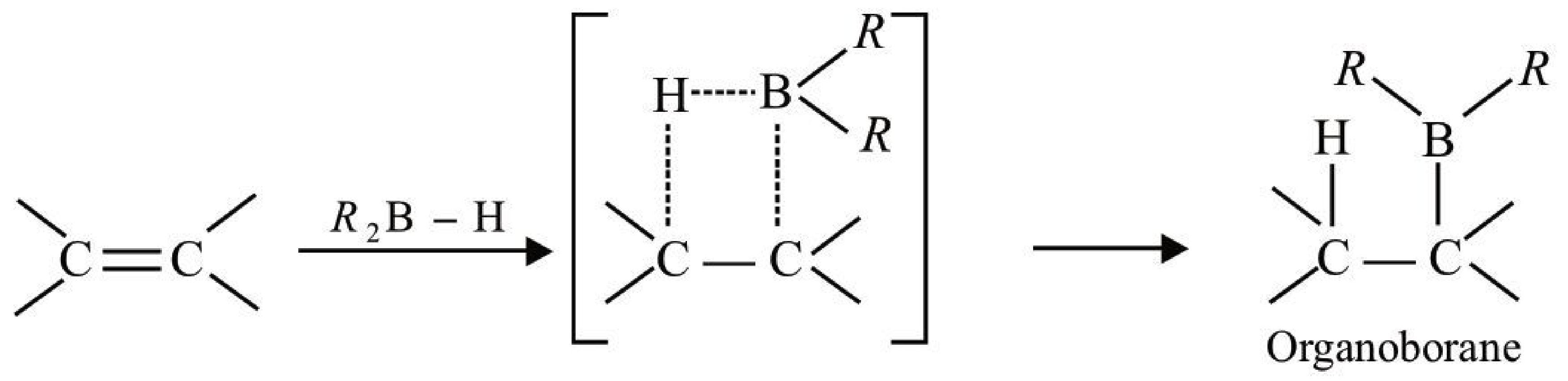
Intramolecular aldol condensation :



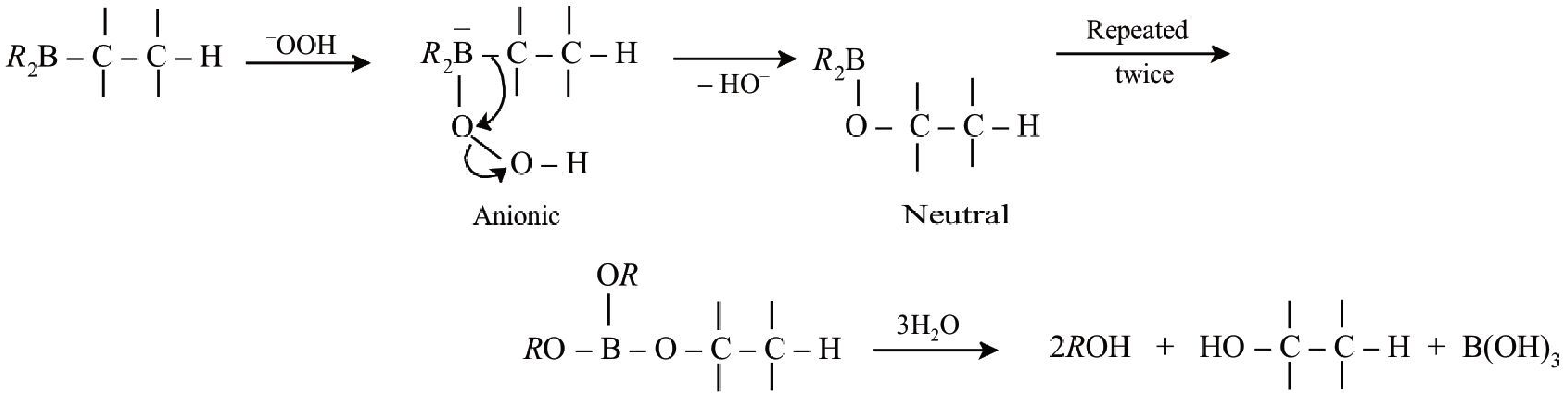
HYDROBORATION

Mechanism

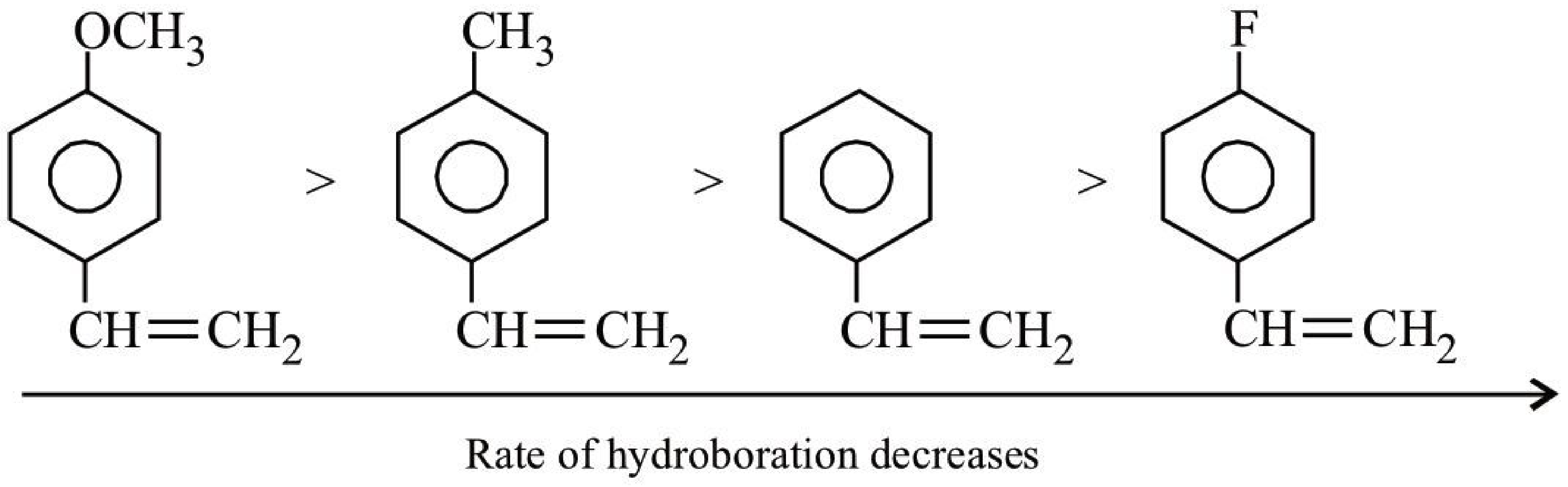
Hydroboration is a stereospecific reaction. Two atoms get attached to the same side of the double bond means a *cis*-addition.


R_2B-H
H
B
R
R
C
C
Organoborane

The organoborane is then attacked by nucleophile hydroperoxide anion during oxidation.


$^-$OOH
– HO$^-$
Repeated twice
Anionic
Neutral
3H$_2$O
2ROH + HO – C – C – H + B(OH)$_3$

The rate of hydroboration of 1-alkene ($RCH = CH_2$) is nearly independent of the length of the straight chain. However, branching in the R group decreases the rate of hydroboration.


OCH$_3$
CH$_3$
F
CH=CH$_2$
>
Rate of hydroboration decreases

Unlike other electrophilic addition reactions, on alkenes which follow two-step mechanism, hydroboration follows a single-step mechanism. Electrophilic nature of hydroboration is evident from the following observation. With electron-donating substituents, the rate of hydroboration is higher.

◆ ◆

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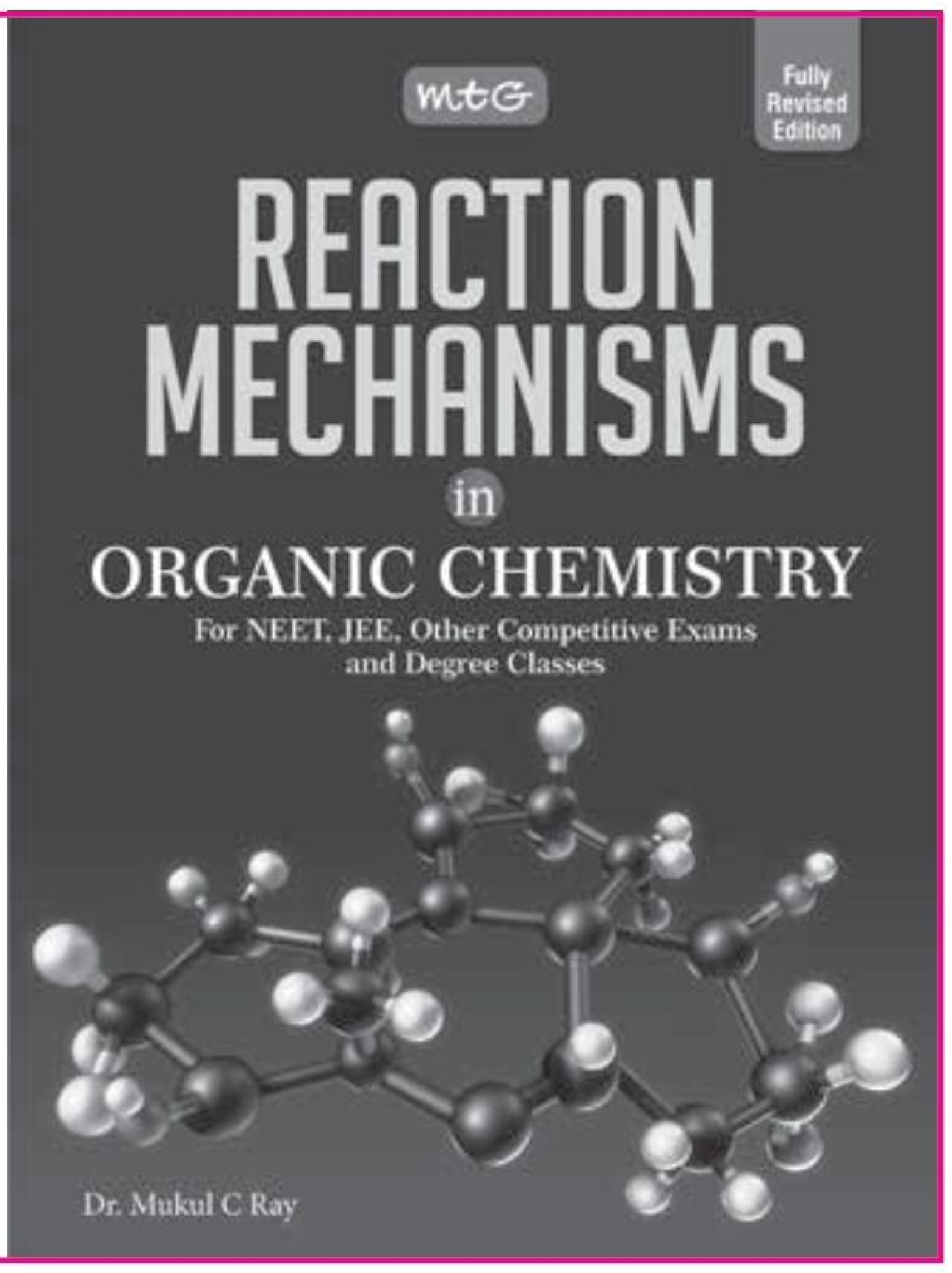
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CBSE warm-up!

CLASS-XII

Chapterwise practice questions for CBSE Exams as per the latest pattern and reduced syllabus by CBSE for the academic session 2022-23.

Series-8 Aldehydes, Ketones and Carboxylic Acids

Time Allowed : 3 hours
Maximum Marks : 70

GENERAL INSTRUCTIONS

General Instructions : Read the following instructions carefully.

(a) There are 35 questions in this question paper with internal choice.
(b) SECTION A consists of 18 multiple-choice questions carrying 1 mark each.
(c) SECTION B consists of 7 very short answer questions carrying 2 marks each.
(d) SECTION C consists of 5 short answer questions carrying 3 marks each.
(e) SECTION D consists of 2 case- based questions carrying 4 marks each.
(f) SECTION E consists of 3 long answer questions carrying 5 marks each.
(g) All questions are compulsory.
(h) Use of log tables and calculators is not allowed.

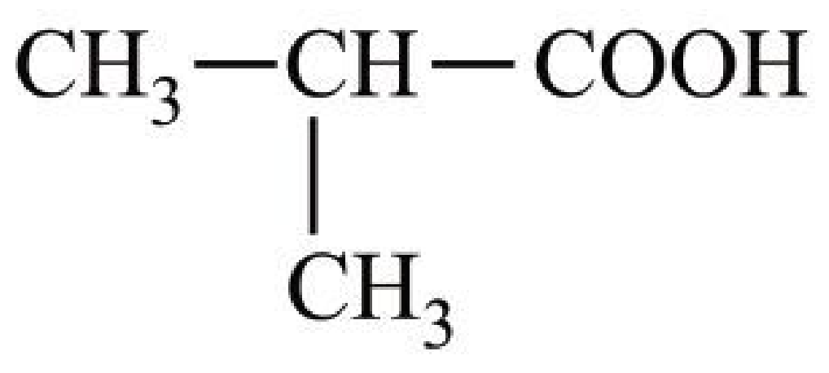
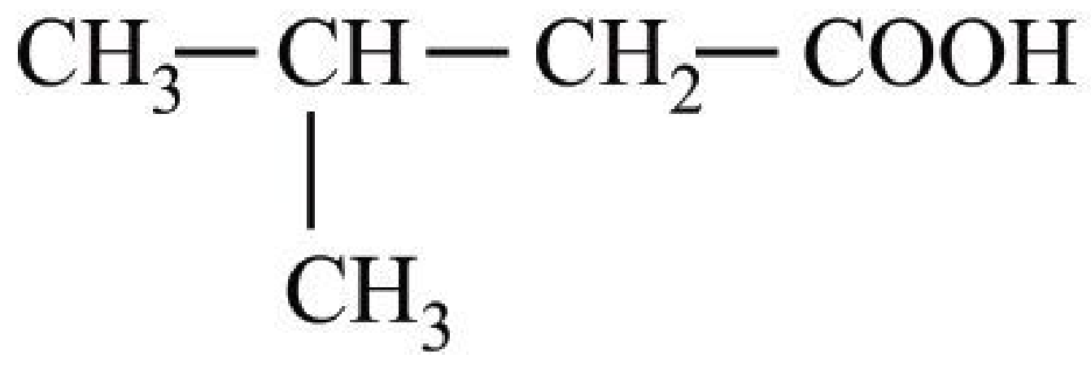
SECTION A

The following questions are multiple-choice questions with one correct answer. Each question carries 1 mark. There is no internal choice in this section.

1. Which of the following will not give aldol condensation?
(a) Phenyl acetaldehyde (b) 2-Methylpentanal
(c) Benzaldehyde (d) 1-Phenylpropanone

2. The correct order of increasing acidic strength is
(a) Phenol < Ethanol < Chloroacetic acid < Acetic acid
(b) Ethanol < Phenol < Chloroacetic acid < Acetic acid
(c) Ethanol < Phenol < Acetic acid < Chloroacetic acid
(d) Chloroacetic acid < Acetic acid < Phenol < Ethanol

3. What happens when a carboxylic acid is treated with lithium aluminium hydride?
(a) Aldehyde is formed.
(b) Primary alcohol is formed.
(c) Ketone is formed.
(d) Grignard reagent is formed.

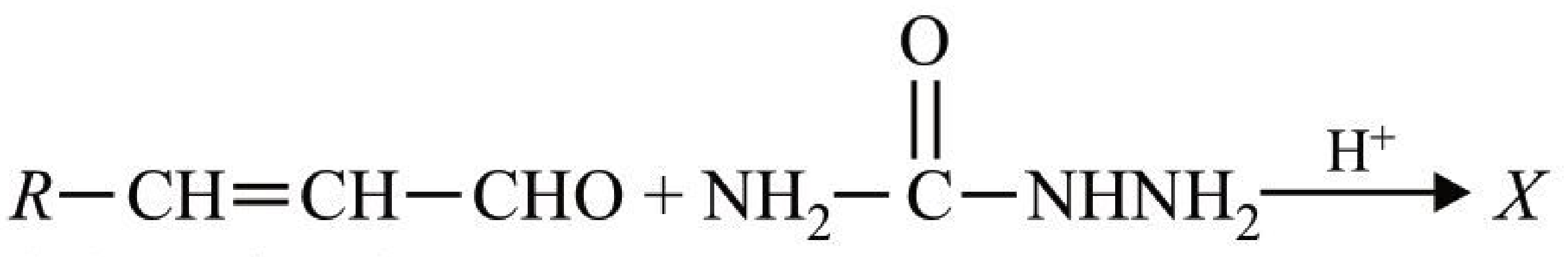
4. Various products formed on oxidation of 2,5-dimethylhexan-3-one are
(i) 
$CH_3-\underset{\underset{CH_3}{|}}{CH}-COOH$
(ii) 
$CH_3-\underset{\underset{CH_3}{|}}{CH}-CH_2-COOH$
(iii) CH_3COOH
(iv) HCOOH
(a) (i) and (iii) (b) (i), (ii) and (iii)
(c) (i), (ii), (iii) and (iv) (d) (iii) and (iv)

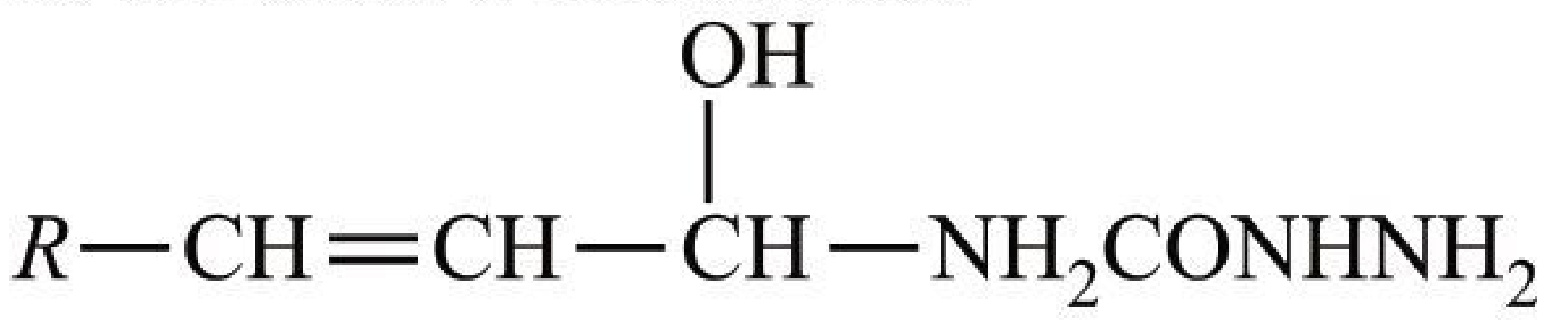
5. Aldehydes other than formaldehyde react with Grignard's reagent to give addition products which on hydrolysis give

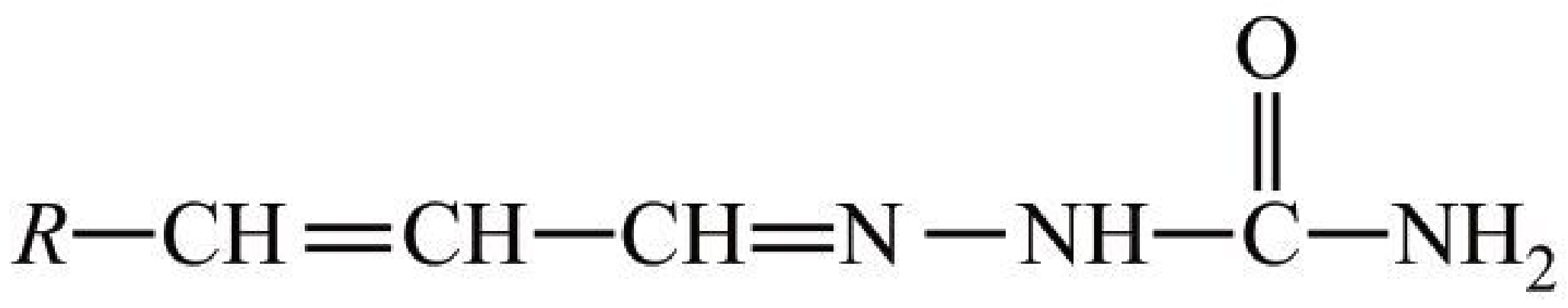
(a) tertiary alcohols (b) secondary alcohols
(c) primary alcohols (d) carboxylic acids.

6. To differentiate between pentan-2-one and pentan-3-one a test is carried out. Which of the following is the correct answer?
(a) Pentan-2-one will give silver mirror test.
(b) Pentan-2-one will give iodoform test.
(c) Pentan-3-one will give iodoform test.
(d) None of these.

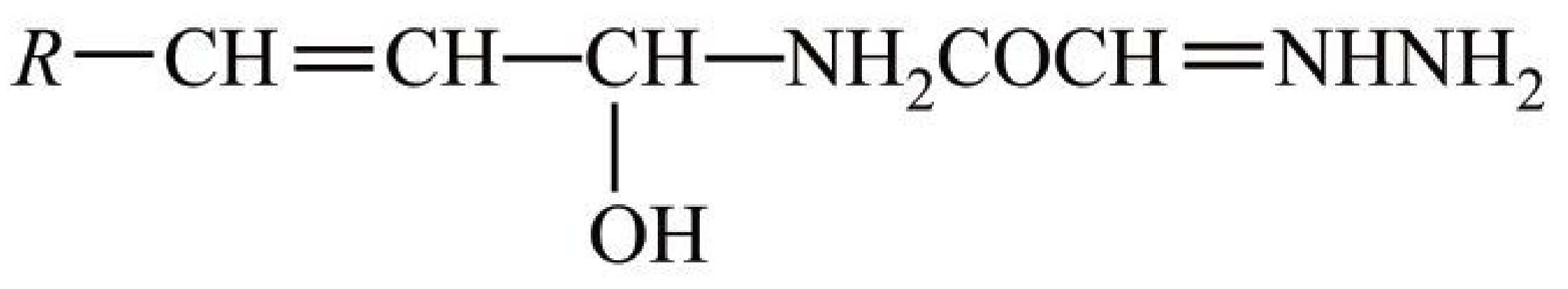
7. The addition of HCN to carbonyl compounds is an example of
(a) nucleophilic addition (b) electrophilic addition
(c) free radical addition (d) electromeric addition.

8. 
$R-CH=CH-CHO + NH_2-\overset{O}{\overset{\|}{C}}-NHNH_2 \xrightarrow{H^+} X$
(X) in the above reaction is

(a) 
$R-CH=CH-\underset{}{\overset{OH}{\overset{|}{CH}}}-NH_2CONHNH_2$

(b) 
$R-CH=CH-CH=N-NH-\overset{O}{\overset{\|}{C}}-NH_2$

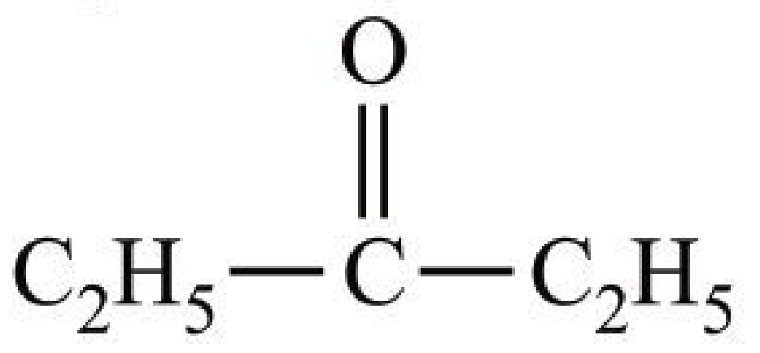
(c) $R-CH=NH_2CONH_2$

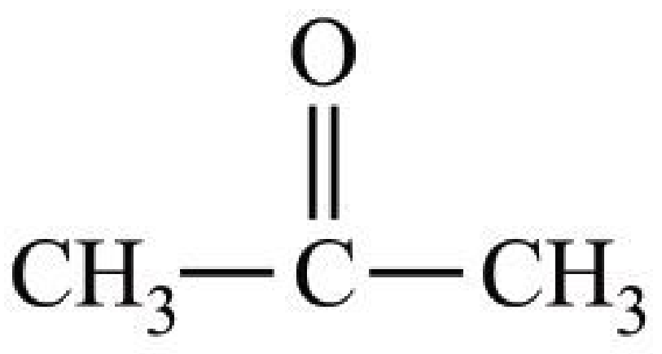
(d) 
$R-CH=CH-\underset{\underset{OH}{|}}{CH}-NH_2COCH=NHNH_2$

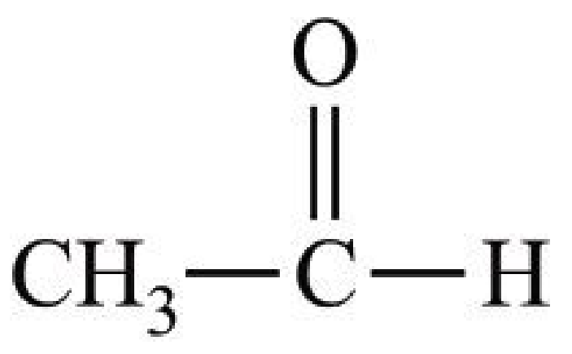
9. Arrange the following compounds in increasing order of their reactivity in nucleophilic addition reactions.
Ethanal, Propanal, Propanone, Butanone
(a) Butanone < Propanone < Propanal < Ethanal
(b) Propanone < Butanone < Ethanal > Propanal
(c) Propanal < Ethanal < Propanone < Butanone
(d) Ethanal < Propanal < Propanone < Butanone

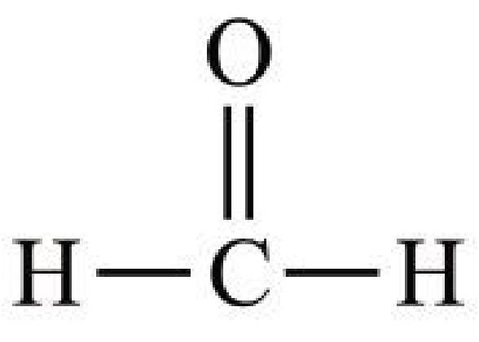
10. The nucleophilic attack of HCN on carbonyl compounds yields
(a) ester (b) amide
(c) cyanohydrin (d) carboxylic acid.

11. Which of the following carbonyl compounds is most polar?

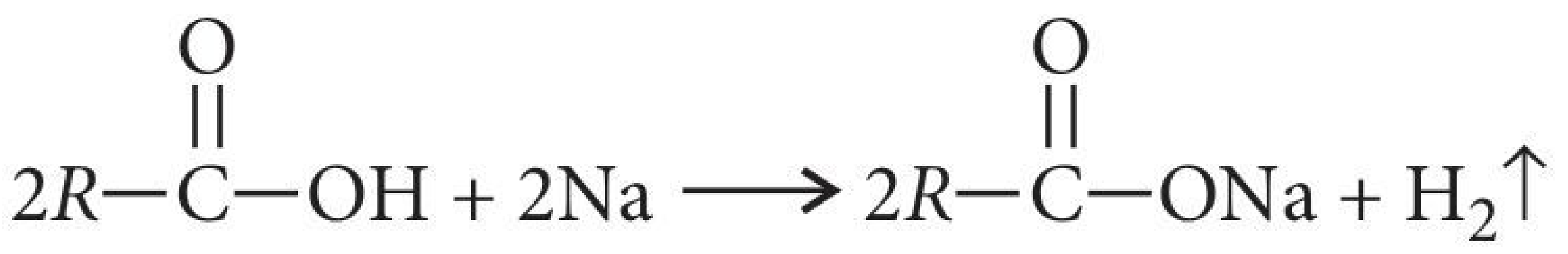
(a) 
$C_2H_5-\overset{O}{\overset{\|}{C}}-C_2H_5$

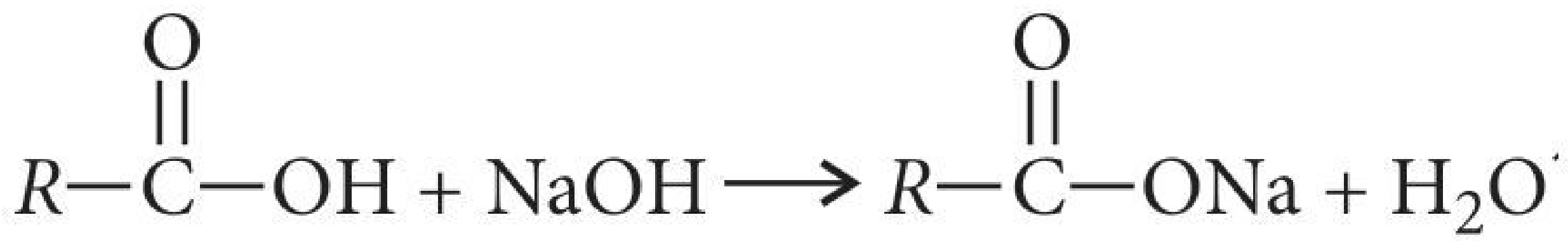
(b) 
$CH_3-\overset{O}{\overset{\|}{C}}-CH_3$

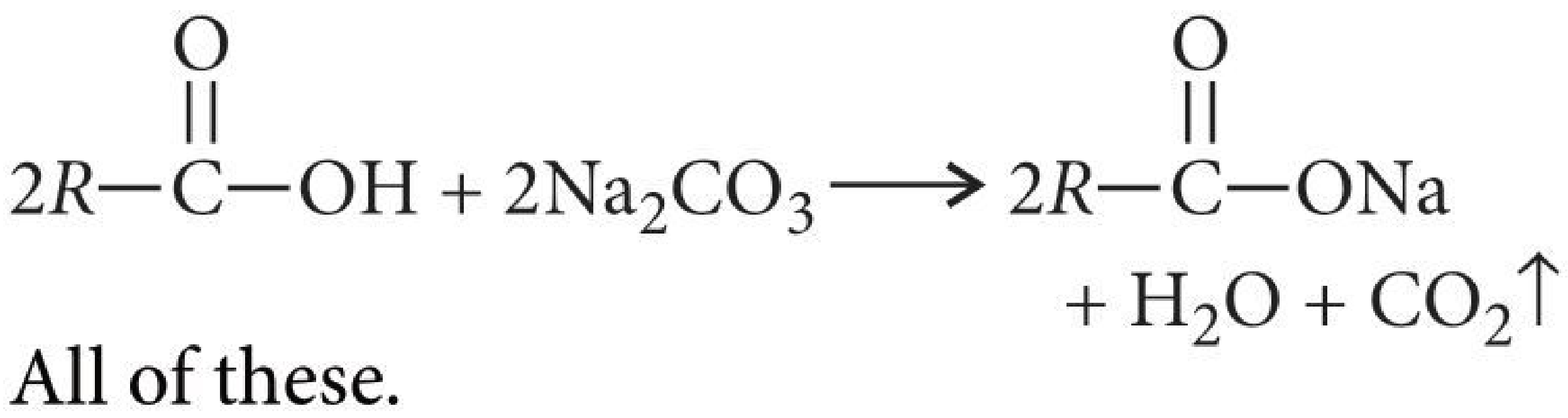
(c) 
$CH_3-\overset{O}{\overset{\|}{C}}-H$

(d) 
$H-\overset{O}{\overset{\|}{C}}-H$

12. Which of the following reactions is showing the acidic property of carboxylic acid?

(a) 
$2R-\overset{O}{\overset{\|}{C}}-OH + 2Na \longrightarrow 2R-\overset{O}{\overset{\|}{C}}-ONa + H_2\uparrow$

(b) 
$R-\overset{O}{\overset{\|}{C}}-OH + NaOH \longrightarrow R-\overset{O}{\overset{\|}{C}}-ONa + H_2O$

(c) 
$2R-\overset{O}{\overset{\|}{C}}-OH + 2Na_2CO_3 \longrightarrow 2R-\overset{O}{\overset{\|}{C}}-ONa + H_2O + CO_2\uparrow$

(d) All of these.

13. Which of the following reaction will not result in the formation of carbon-carbon bonds?
(a) Cannizzaro reaction
(b) Wurtz reaction
(c) Reimer-Tiemann reaction
(d) Friedel-Crafts' acylation

14. Which of the following compounds would be the main product of an aldol condensation of acetaldehyde and acetone?
(a) $CH_3CH=CHCHO$ (b) $CH_3CH=CHCOCH_3$
(c) $(CH_3)_2C=CHCHO$ (d) $(CH_3)_2C=CHCOCH_3$

15. Given below are two statements labelled as Assertion (A) and Reason (R).

Assertion (A) : α-Hydrogen atoms in aldehydes and ketones are acidic.
Reason (R) : The anion left after the removal of α-hydrogen is stabilised by inductive effect.
Select the most appropriate answer from the options given below:
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

16. Given below are two statements labelled as Assertion (A) and Reason (R).

Assertion (A) : Fluoroacetic acid is stronger than chloroacetic acid.
Reason (R) : Carboxylic acids are weak acids and turn blue litmus red.
Select the most appropriate answer from the options given below:
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

17. Given below are two statements labelled as Assertion (A) and Reason (R).

Assertion (A) : Lower aldehydes and ketones are soluble in water but the solubility decreases as the molecular mass increases.

Reason (R) : Distinction between aldehydes and ketones can be done by Tollens' test.

Select the most appropriate answer from the options given below:

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

18. Given below are two statements labelled as Assertion (A) and Reason (R).

Assertion (A) : Carboxylic acids are stabilised by resonance.

Reason (R) : Chloroacetic acid is weaker than acetic acid.

Select the most appropriate answer from the options given below:

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

SECTION B

This section contains 7 questions with internal choice in two questions. The following questions are very short answer type and carry 2 marks each.

19. How will you obtain an aldehyde by using following process?

(a) Catalytic dehydrogenation.
(b) Catalytic hydrogenation.

20. Give reason for the following :

The boiling points of aldehydes and ketones are lower than the corresponding alcohols.

OR

Aldehydes are more volatile than the corresponding alcohols.

21. Complete the following reactions :

(a) $CH_3CHO \xrightarrow{NaOH}$

(b) $(A) \xrightarrow[C_2H_5ONa]{NH_2NH_2} CH_3CH_2CH_3$

22. Give chemical reaction to illustrate the acylation reaction.

OR

What happens when carboxylic acid reacts with metals?

23. What is Kolbe's electrolysis? Give example.

24. The C – O bond in carboxylic acid is shorter than that in alcohol. Explain.

25. Benzoic acid does not undergo Friedel-Crafts reaction. Why?

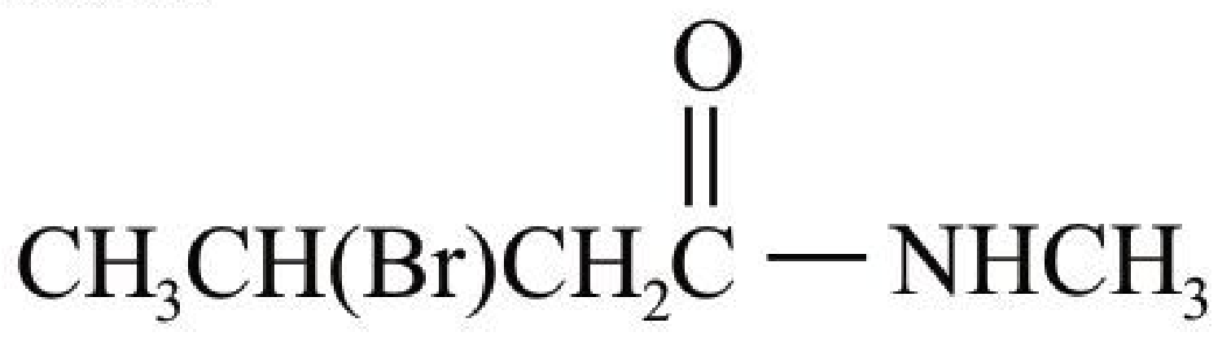
SECTION C

This section contains 5 questions with internal choice in two questions. The following questions are short answer type and carry 3 marks each.

26. (a) Write chemical equation to illustrate each of the following reactions :

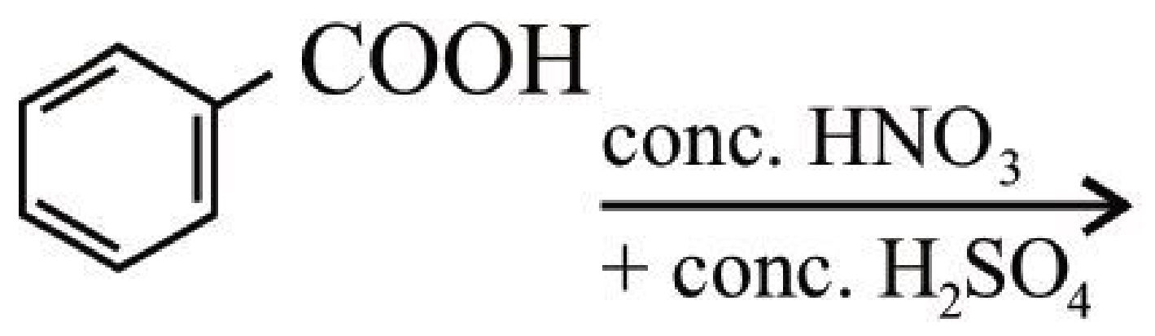
(i) Clemmensen reduction
(ii) Rosenmund reduction

(b) Write the IUPAC name of the following compound :

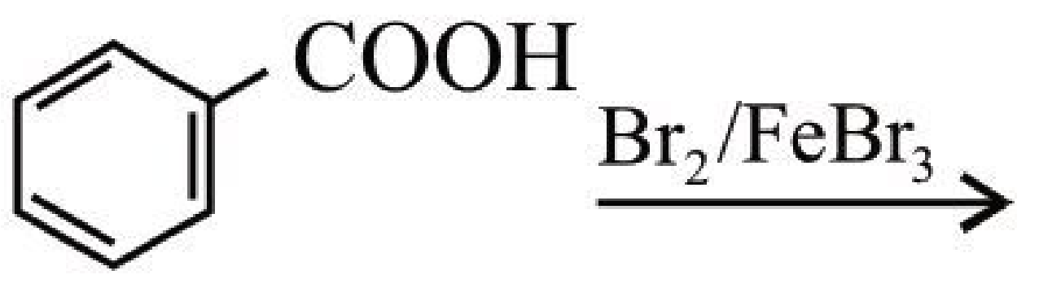


$$CH_3CH(Br)CH_2\overset{\overset{O}{\|}}{C}—NHCH_3$$

27. Predict the product.

(i) 

$$C_6H_5COOH \xrightarrow[+\ conc.\ H_2SO_4]{conc.\ HNO_3}$$

(ii) 

$$C_6H_5COOH \xrightarrow{Br_2/FeBr_3}$$

28. Treatment of benzaldehyde with HCN gives a mixture of two isomers which cannot be separated even by careful fractional distillation. Explain.

OR

Draw the structure of a carbonyl group and indicate clearly:

(i) the hybridized state of carbon,
(ii) the σ and π bonds present and
(iii) the electrophilic and nucleophilic centres in it.

29. Write the series of reactions which would convert:

(a) Ethanol into propanone
(b) Phenol into benzaldehyde.

30. Give reasons for **any three** of the following :

(a) Boiling points of carboxylic acids are higher than those of corresponding alcohols.
(b) The C — O bond length in *R*COOH is shorter than in *R* — OH.
(c) Acetic acid in vapour state has a molecular mass of 120.
(d) Discuss the mechanism of esterification of carboxylic acids.

SECTION D

The following questions are case-based questions. Each question has an internal choice and carries 4 (1+1+2) marks each. Read the passage carefully and answer the questions that follow.

31. Aldehydes and ketones are reduced to primary and secondary alcohols respectively by $NaBH_4$ or $LiAlH_4$ as well as catalytic hydrogenation.

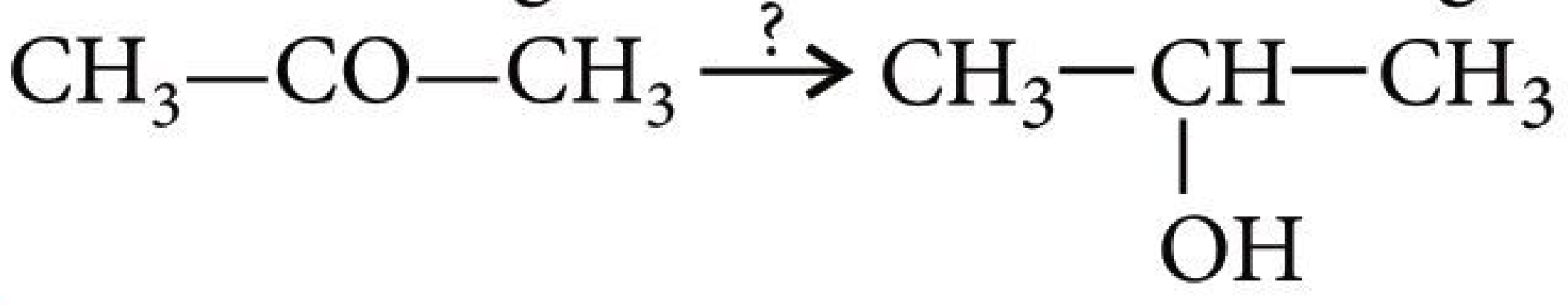
The carbonyl group of aldehydes and ketones is reduced to $>CH_2$ group by Clemmensen reduction or Wolff-Kishner reduction.

Aldehydes differ from ketones in their oxidation reactions. Aldehydes are easily oxidised to carboxylic acids on treatment with HNO_3, $KMnO_4$, $K_2Cr_2O_7$ etc. Even mild oxidising agents mainly Tollens' reagent and Fehling's solution also oxidise aldehydes. Ketones are generally oxidised under vigorous conditions *i.e.*, strong oxidising agents and at elevated temperatures, to give mixture of carboxylic acids having lesser number of C-atoms than the parent ketone.

Answer the following questions :

(i) What is Tollens' reagent? Write one usefulness of this reagent.

(ii) Name the reagent used in the following reaction :



$$CH_3—CO—CH_3 \xrightarrow{?} CH_3—\underset{\substack{|\\OH}}{CH}—CH_3$$

(iii) Describe how the following conversion can be brought about :

Cyclohexanol to cyclohexan 1-one

OR

What happens when primary alcohols are oxidised by potassium permanganate, write chemical equation.

32. Carboxylic acids having an α-hydrogen atom when treated with chlorine or bromine in the presence of small amount of red phosphorus gives α-halocarboxylic acids. The reaction is known as Hell-Volhard-Zelinsky reaction.

Answer the following questions :

(i) Why $(CH_3)_3CCOOH$ does not give HVZ reaction?

(ii) Why iodine is not used in HVZ reaction?

(iii) Why red phosphorous is used in HVZ?

OR

Identify the products *A* and *B* in the given sequence of reactions.

$$CH_3CH_2COOH + Br_2 \xrightarrow{\text{Red P}} A \xrightarrow{Br_2/P} B \xrightarrow{Cl_2/\text{Red P}}$$

SECTION E

The following questions are long answer type and carry 5 marks each. Two questions have an internal choice.

33. Distinguish between :

(i) Acetaldehyde and Propanone

(ii) Acetone and Formaldehyde

(iii) Ethyl alcohol and Acetaldehyde

(iv) 2-Pentanone and 3-Pentanone

(v) Propanol and Propanone.

Give chemical equations of each.

OR

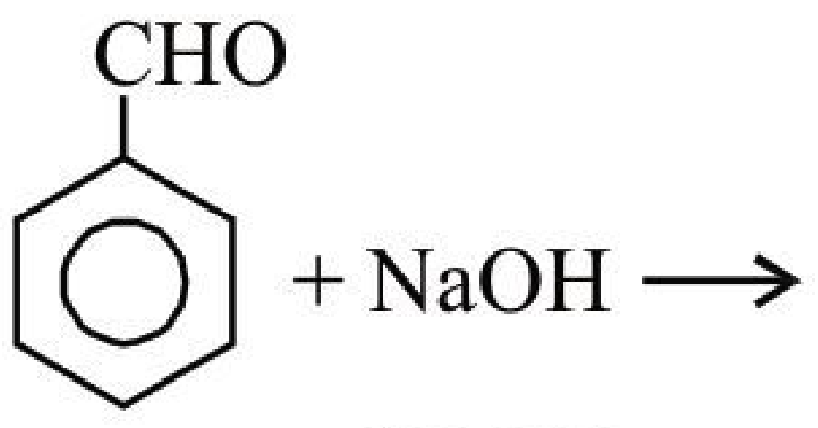
Complete the following sequence of reactions :

(a) $CH_3CHBrCH(CH_3)CH_2CH_3 \xrightarrow[\Delta]{\text{alc. KOH}} \xrightarrow{HBr} \xrightarrow[\text{ether}]{Mg} \xrightarrow{CO_2} \xrightarrow[H^+]{H_2O}$

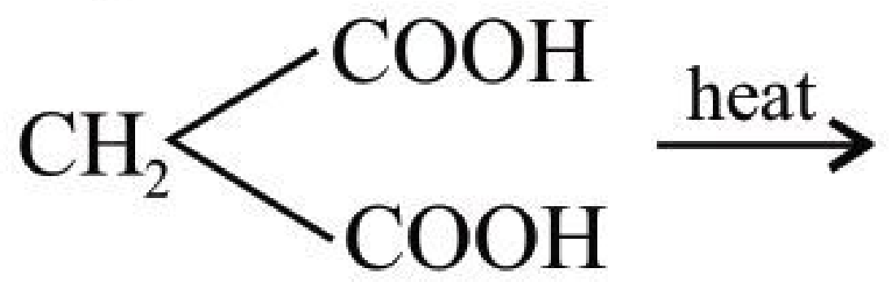
(b) $CH_3—CH_2—COOH \xrightarrow[H^+]{C_2H_5OH} \xrightarrow[\text{(ii) } H_2O]{\text{(i) } C_6H_5MgBr}$

34. Complete the following reactions and identify the final products :

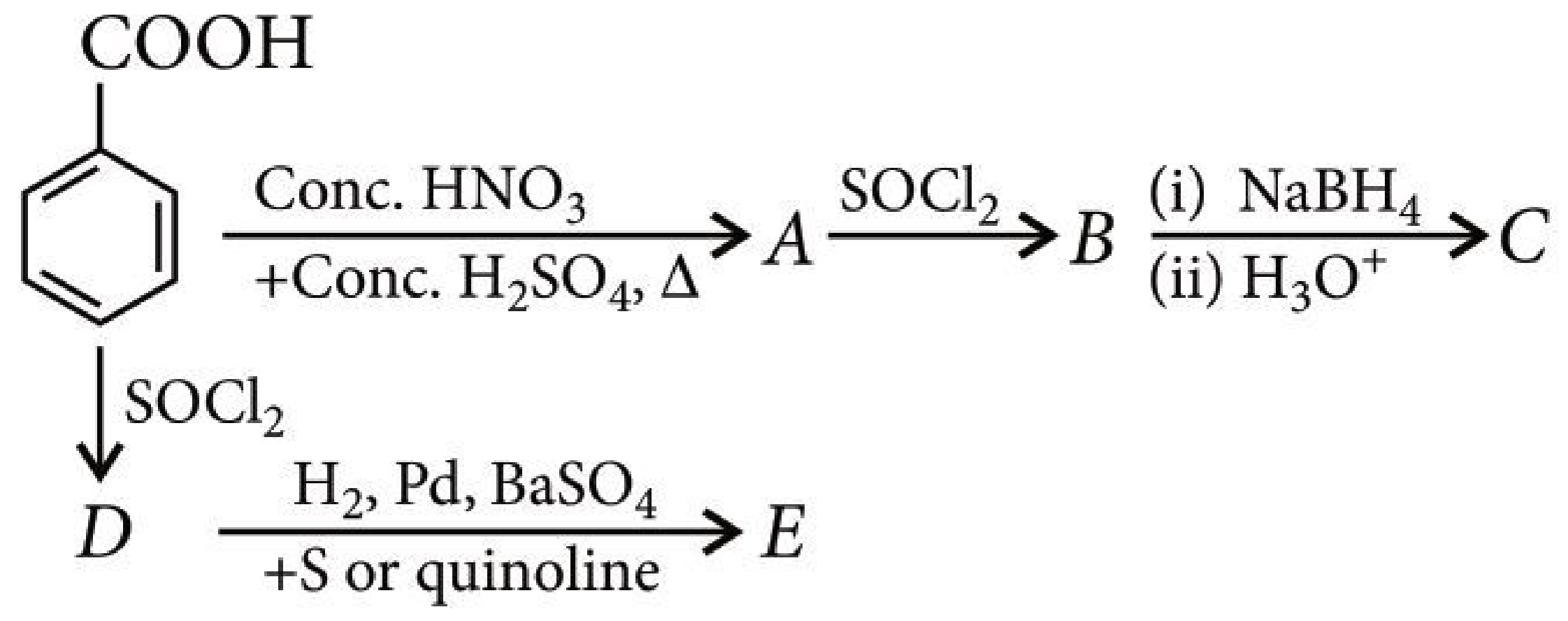
(a) (i)



(ii)



(b) Identify *A* to *E* in the following reactions :



OR

How will you carry out the following conversions :

(i) Acetone to chloroform

(ii) Acetylene to acetic acid

(iii) 1-Bromo-2-methylpropane to 3-methylbutanal

(iv) Ethanal to 1,3-butanediol

(v) Acetophenone to benzoic acid.

35. (a) Write the chemical reactions of acetaldehyde with:

(i) phenylhydrazine

(ii) conc. NaOH solution

(iii) Zn–Hg and conc. HCl

(b) Describe the following :

(i) *Trans*-esterification (ii) Tollens' reagent

SOLUTIONS

1. (c) : Benzaldehyde will not give aldol condensation due to absence of α-H atom.

2. (c) **3. (b)** **4. (c)** **5. (b)**
6. (b) **7. (a)** **8. (b)** **9. (a)**
10. (c) **11. (d)** **12. (d)** **13. (a)**
14. (b)

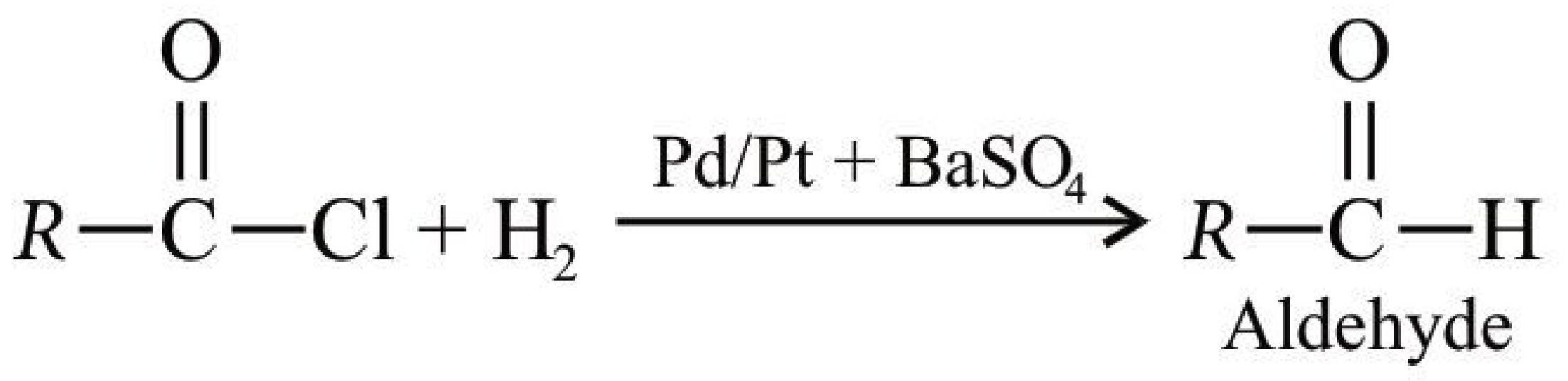
15. (c) : The anion left after the removal of α-hydrogen is stabilized by resonance effect.

16. (b) **17. (b)** **18. (c)**

19. (a) Dehydrogenation in the presence of Cu at 573 K of alcohol gives aldehyde.

$$RCH_2OH \xrightarrow[573\text{ K}]{Cu} RCHO + H_2$$

(b) Acid chlorides can be reduced into aldehydes with hydrogen with Pd or Pt and barium sulphate as catalyst. This reaction is called Rosenmund's reduction.



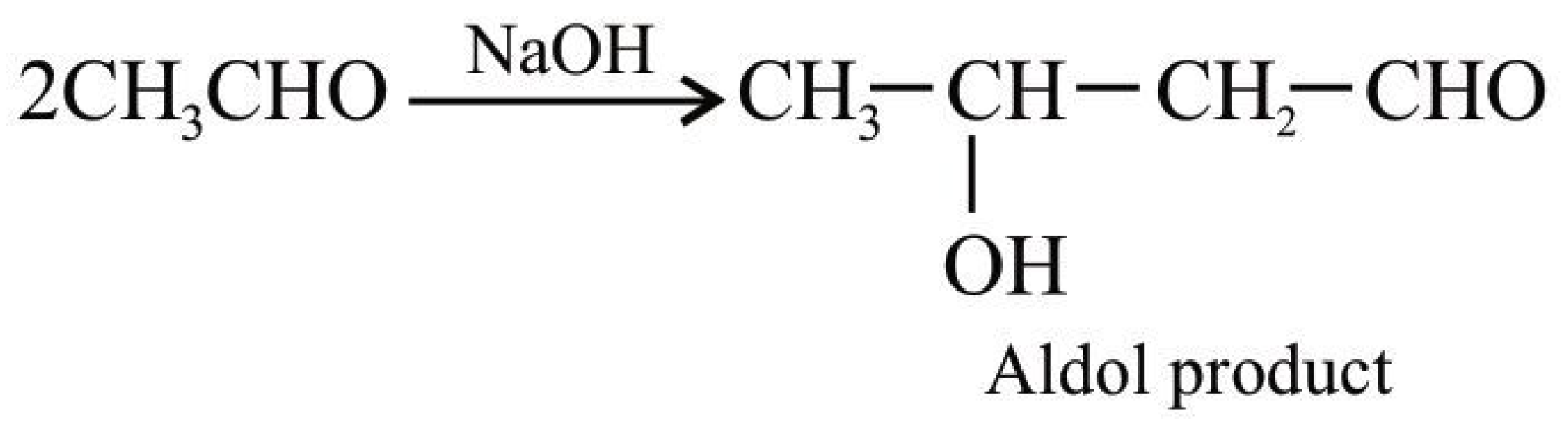
$$R-\overset{\overset{\large O}{\|}}{C}-Cl + H_2 \xrightarrow{Pd/Pt + BaSO_4} \underset{\text{Aldehyde}}{R-\overset{\overset{\large O}{\|}}{C}-H}$$

20. Aldehydes and ketones lack intermolecular H-bonding. So, they have lower boiling points than corresponding alcohols.

OR

Aldehydes do not have intermolecular H–bonding. So, they are more volatile than alcohol because alcohol contains intermolecular H–bonding.

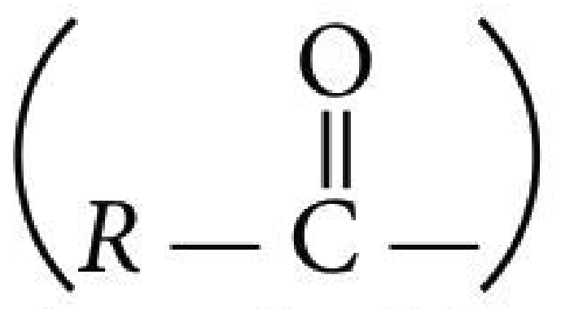
21. (a)



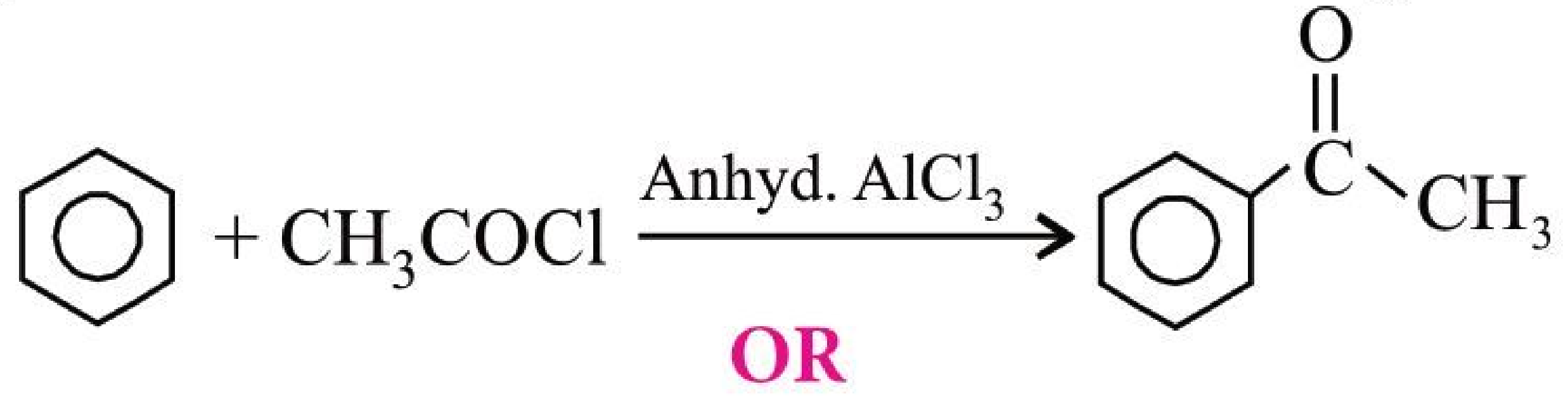
$$2CH_3CHO \xrightarrow{NaOH} \underset{\text{Aldol product}}{CH_3-\underset{\underset{\large OH}{|}}{CH}-CH_2-CHO}$$

(b) $\underset{(A)}{CH_3COCH_3} \xrightarrow[C_2H_5ONa]{NH_2NH_2} CH_3CH_2CH_3$
(Wolff-Kishner reduction)

22. The process of introducing an acyl group



$\left(R-\overset{\overset{\large O}{\|}}{C}-\right)$ into any molecule is called acylation. Acetyl chloride reacts with benzene in presence of anhydrous aluminium chloride to form acetophenone.



OR

Carboxylic acids evolve hydrogen on reaction with metals.

$$2R-COOH + 2Na \longrightarrow 2RCOONa + H_{2(g)}$$

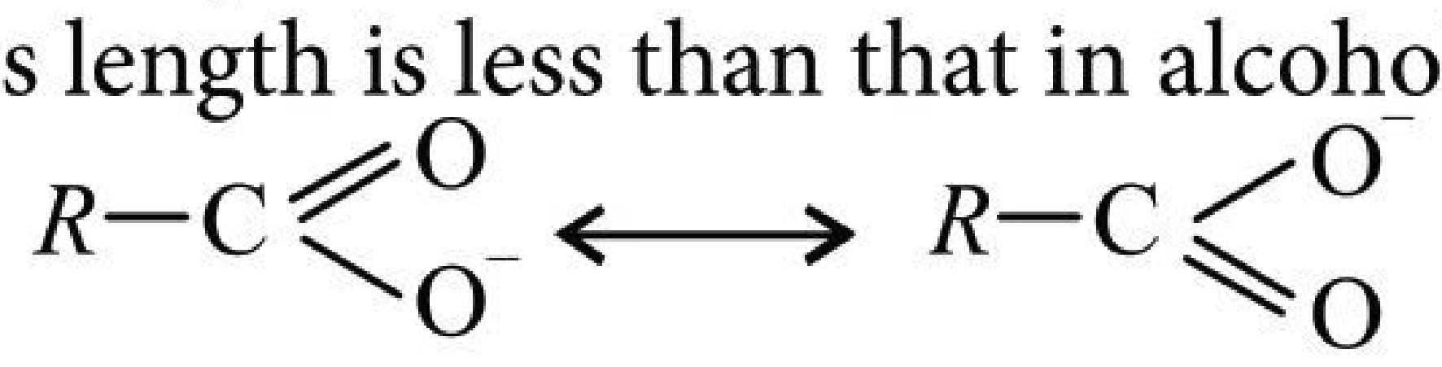
23. Alkali metal salts of carboxylic acids undergo decarboxylation on electrolysis of their aqueous solution and form hydrocarbon having twice the number of carbon atoms present in alkyl group of acid. This reaction is known as Kolbe's electrolysis.

$$2RCOONa \longrightarrow 2RCOO^- + 2Na^+$$

At anode : $2RCOO^- \longrightarrow 2CO_2 + R-R + 2e^-$

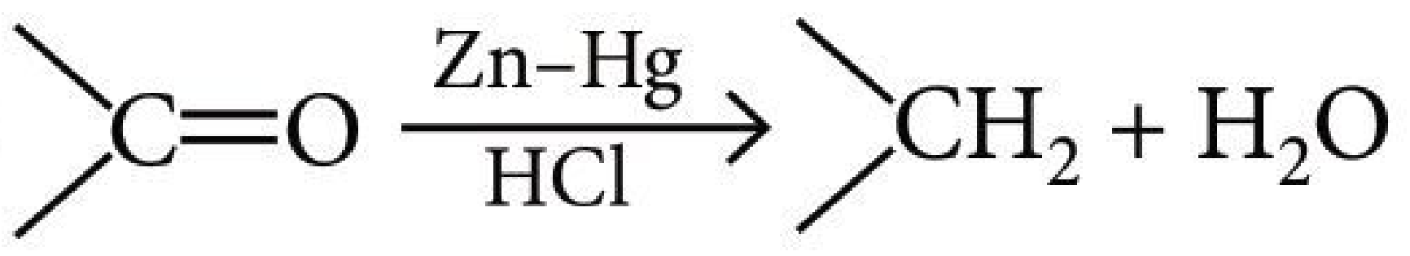
At cathode : $2Na^+ + 2H_2O + 2e^- \longrightarrow 2NaOH + H_2$

24. Due to resonance structure of carboxylate ion the C – O bond acquires some double bond character, due to which its length is less than that in alcohol.

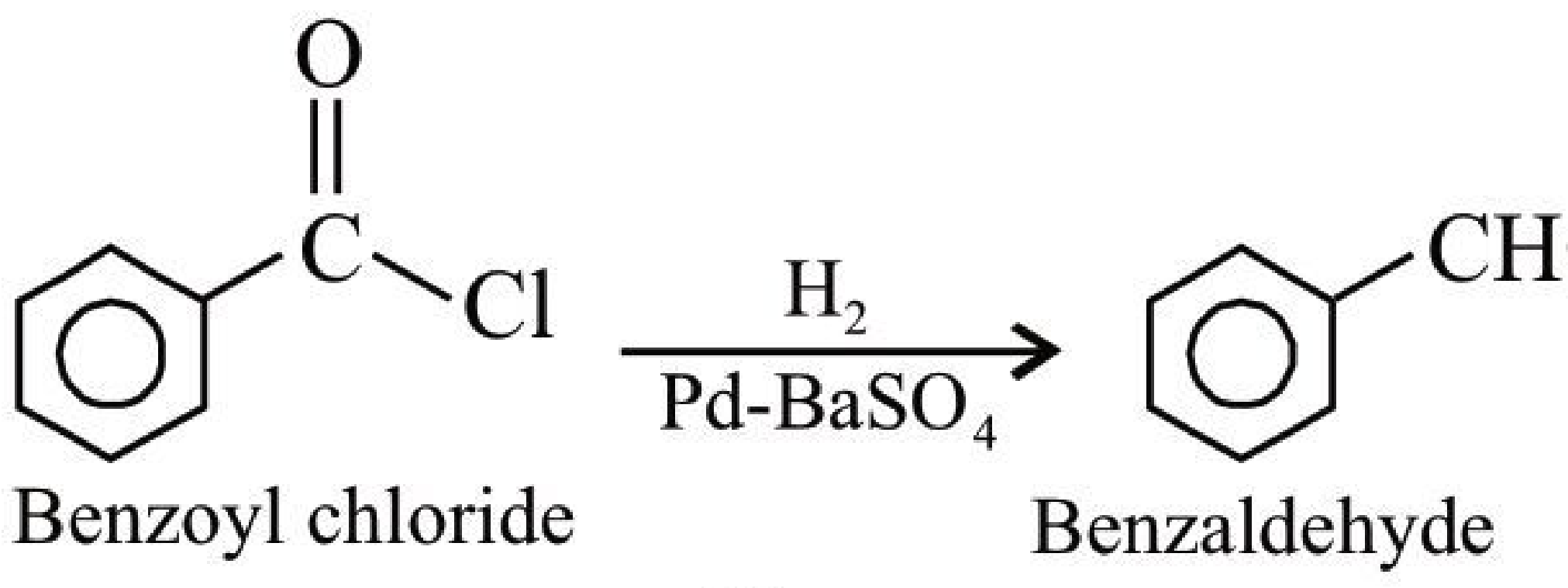


25. Carboxylic group is deactivating group and the catalyst aluminium chloride used in Friedel–Craft's reaction is a Lewis acid so, gets bonded to the carboxyl group. Thus, benzoic acid does not undergo Friedel-Craft's reaction.

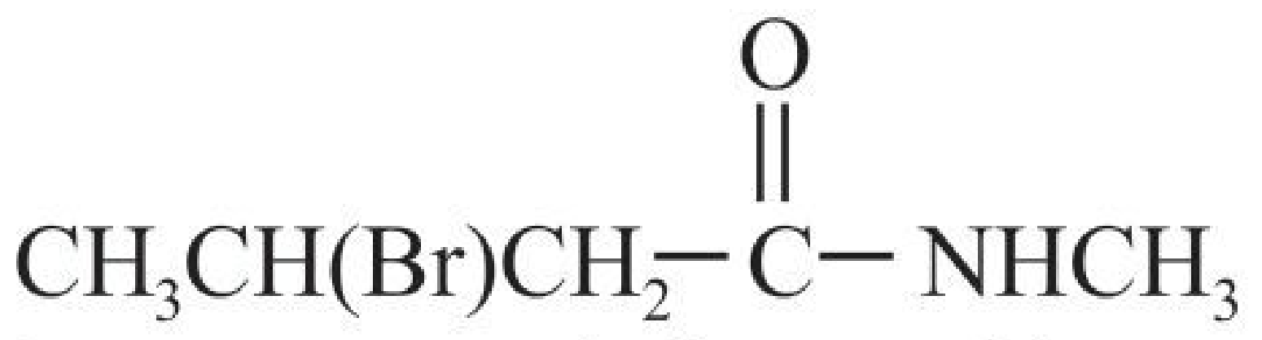
26. (a) (i)



(ii)



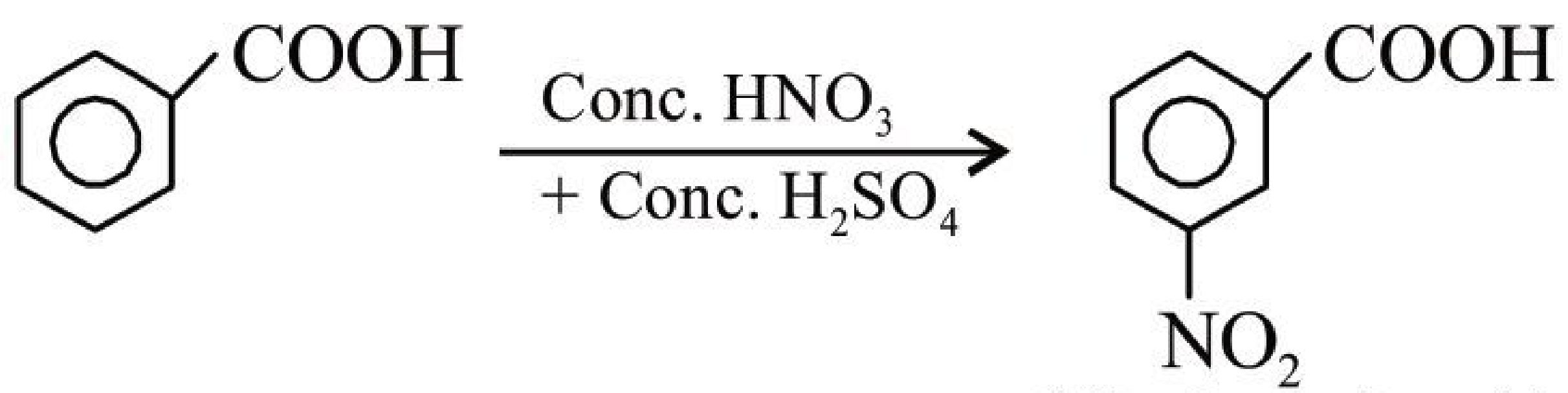
(b)



$$CH_3CH(Br)CH_2-\overset{\overset{\large O}{\|}}{C}-NHCH_3$$

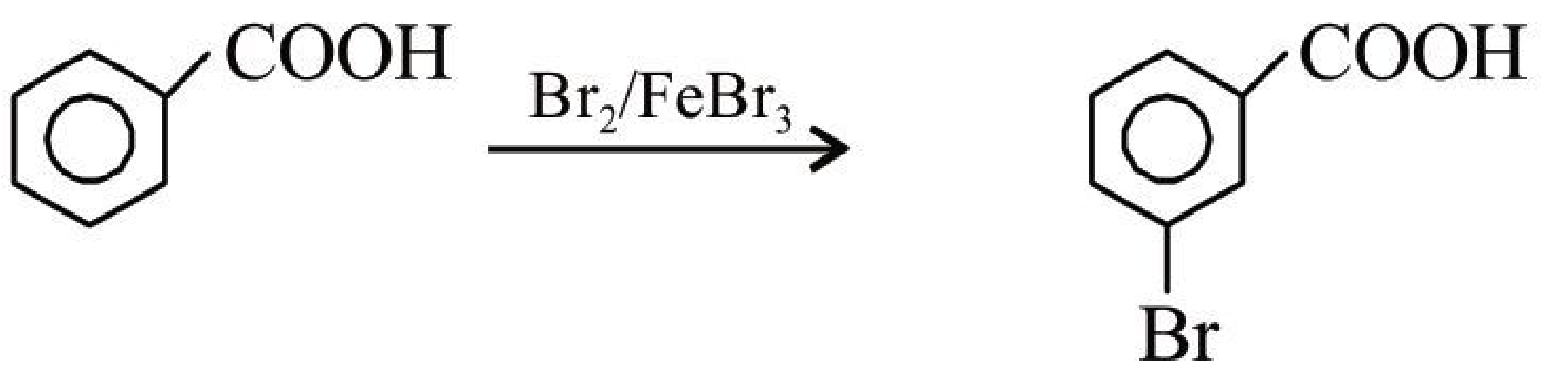
3-Bromo-*N*-methylbutanamide

27. (i)



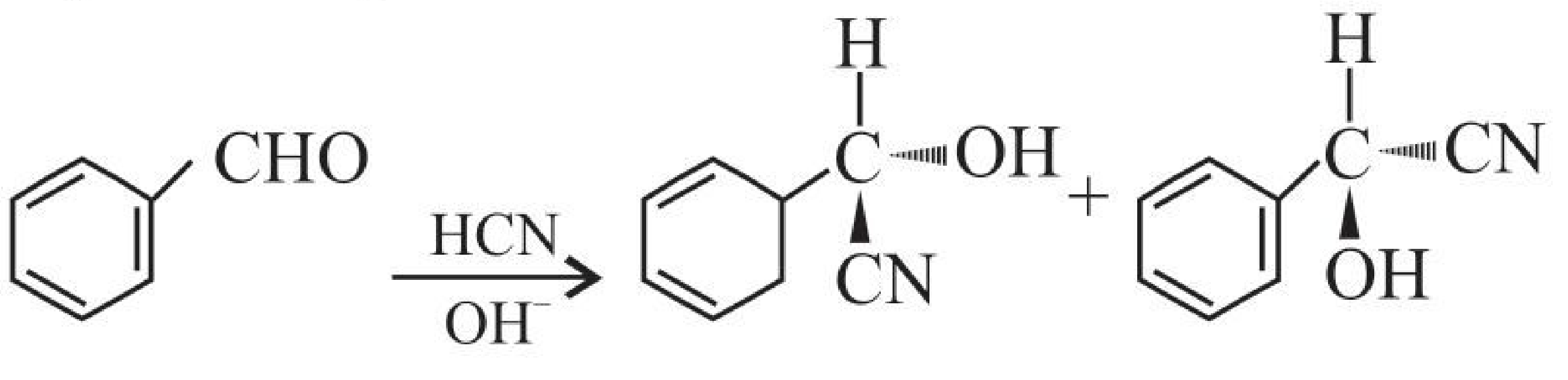
m-Nitrobenzoic acid

(ii)



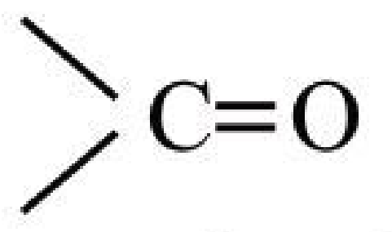
m-Bromobenzoic acid

28. Benzaldehyde on treatment with HCN gives benzaldehyde cyanohydrin which is a chiral molecule and exists as two optical isomers which cannot be separated by fractional distillation.



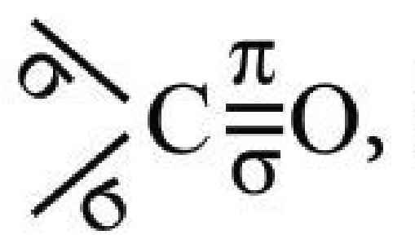
OR

(i)



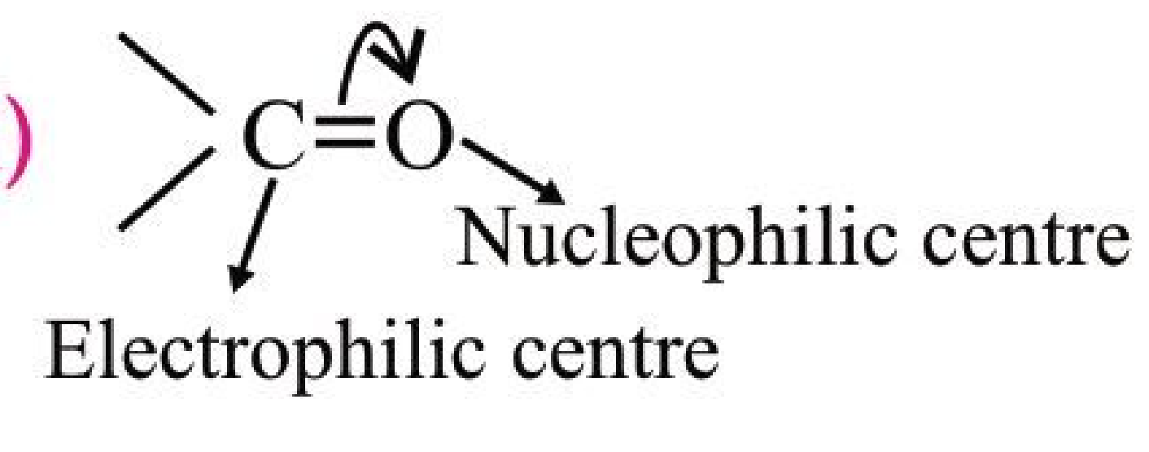
Since carbon has three sigma bonds, so it is sp^2 hybridised.

(ii)



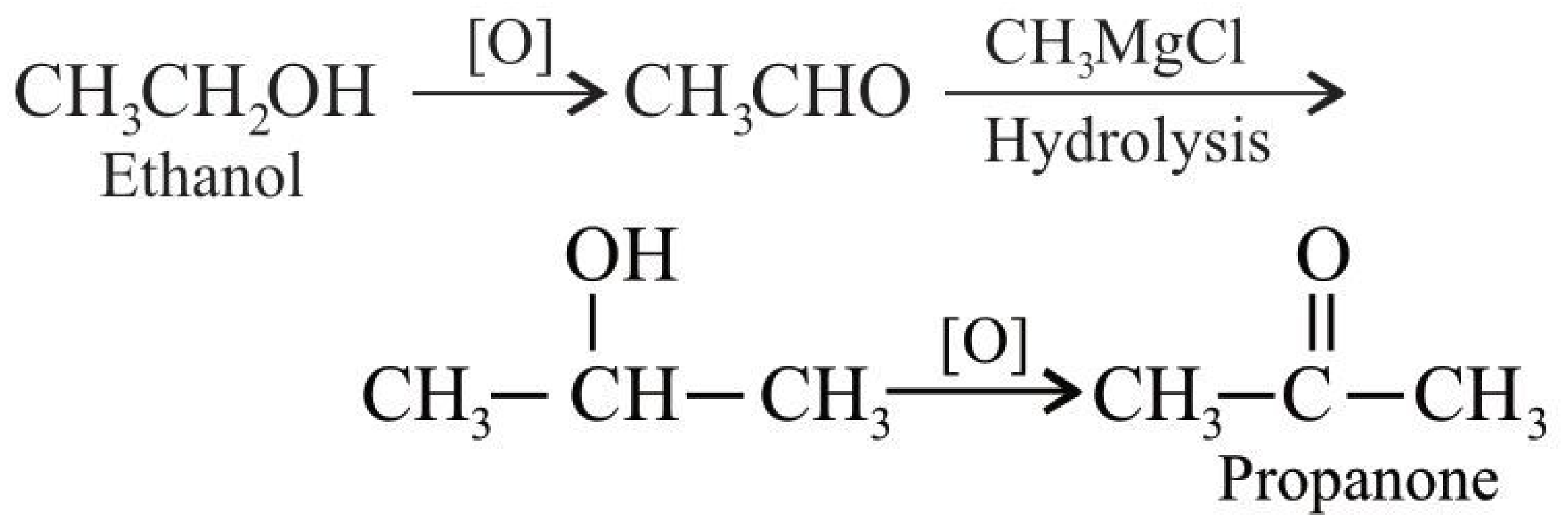
, 3 σ and one π-bond.

(iii)



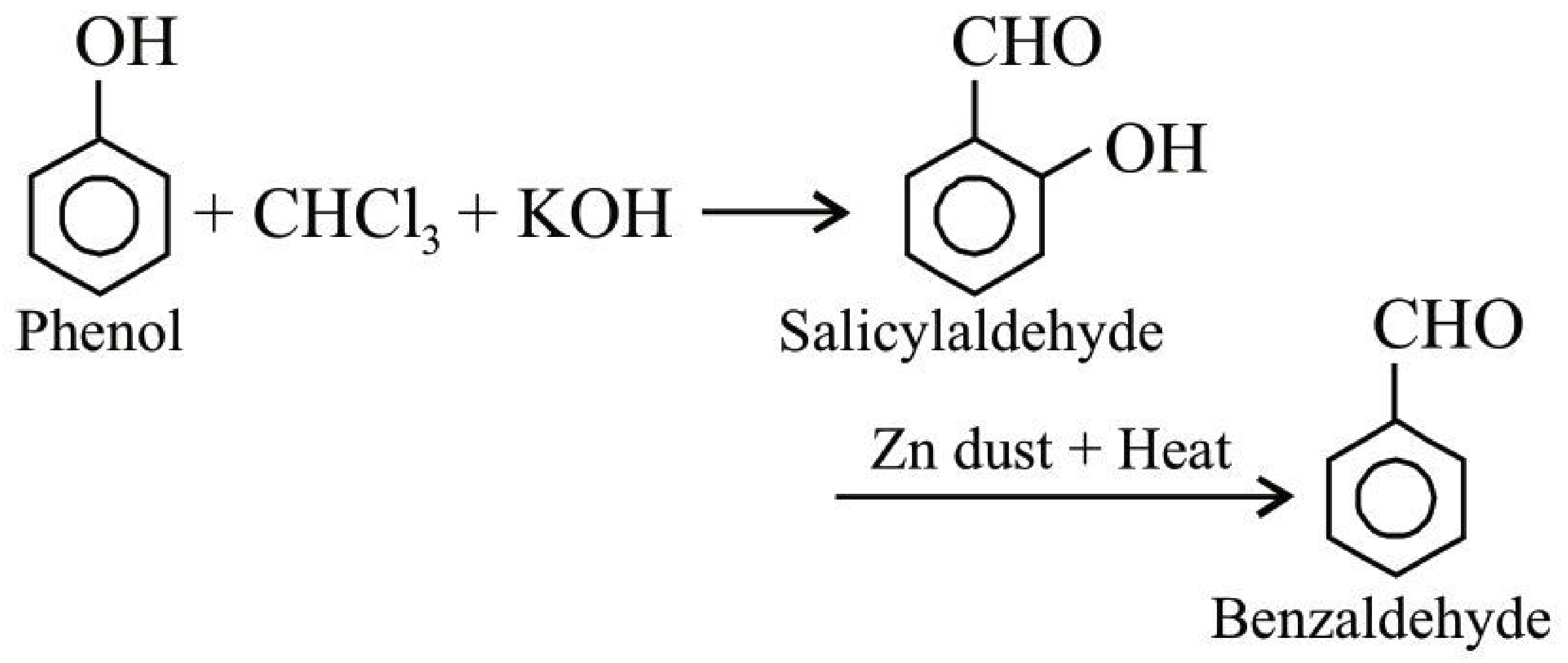
C is electrophilic centre while oxygen behaves as nucleophilic centre.

29. (a)



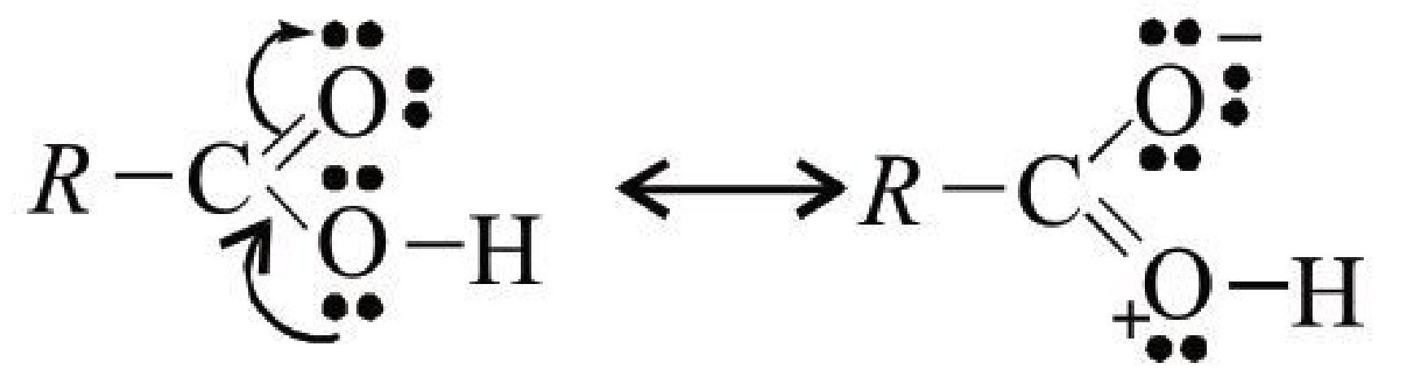
$$\underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow{[O]} CH_3CHO \xrightarrow[\text{Hydrolysis}]{CH_3MgCl} CH_3-\overset{\overset{OH}{|}}{CH}-CH_3 \xrightarrow{[O]} \underset{\text{Propanone}}{CH_3-\overset{\overset{O}{\|}}{C}-CH_3}$$

(b)



30. (a) Higher boiling points of carboxylic acids are due to greater extent of intermolecular hydrogen bonding and dipole-dipole attractions.

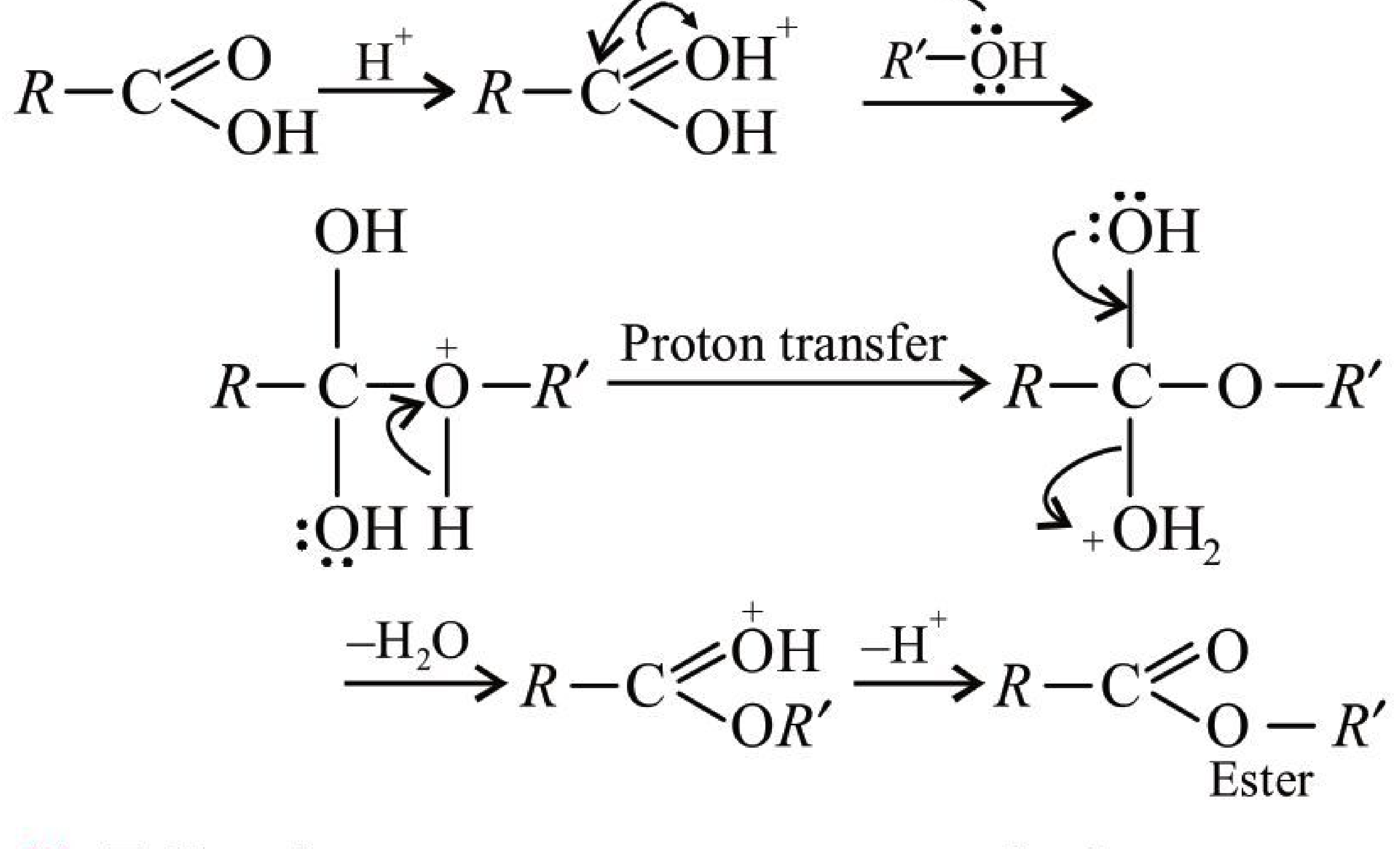
(b) Carboxylic acids show resonance which is not possible in alcohols.



Resonance structures show that the C – O bond of acid has some double bond character, hence shorter in length.

(c) Acetic acid exists as a dimer due to hydrogen bonding hence molecular mass is 120.

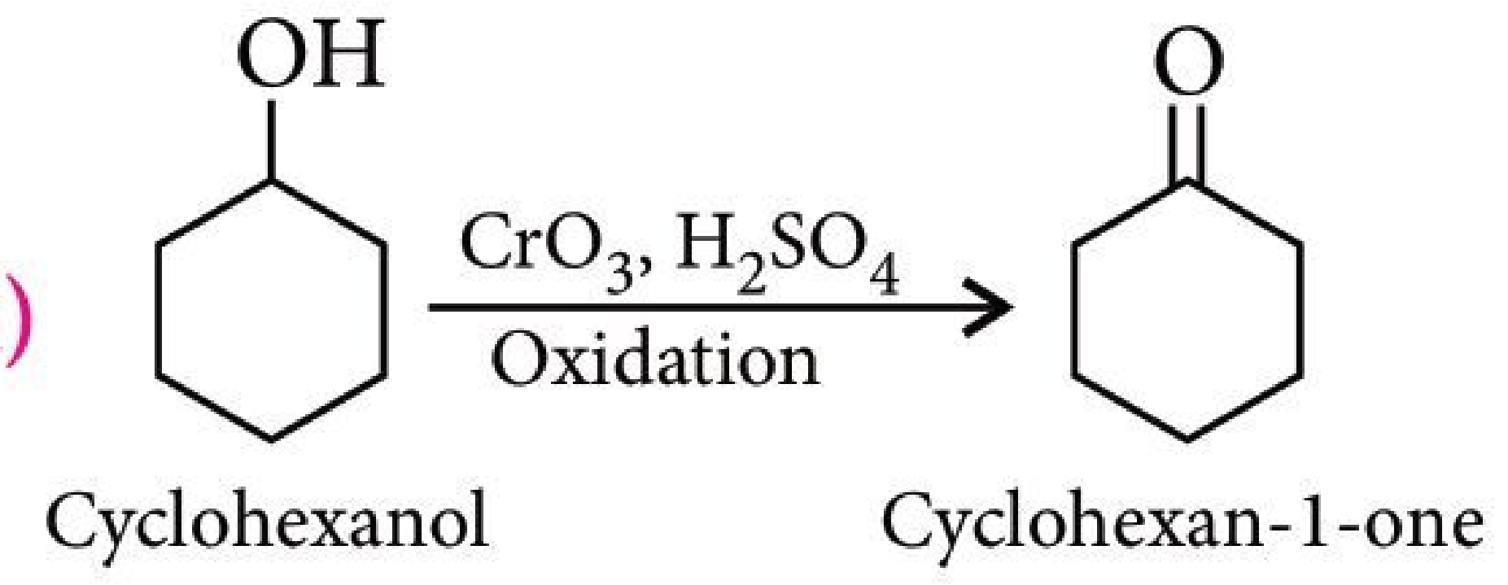
(d)



31. (i) Tollens' reagent is an ammoniacal silver nitrate solution. Tollens' reagent is used to test an aldehyde. Both aliphatic and aromatic aldehydes reduce Tollens' reagent and give silver mirror.

(ii) Lithium aluminium hydride ($LiAlH_4$).

(iii)



OR

$$\underset{\text{Primary alcohol}}{RCH_2OH} \xrightarrow[OH^-]{KMnO_4} \underset{\text{Carboxylic acid}}{RCOOH}$$

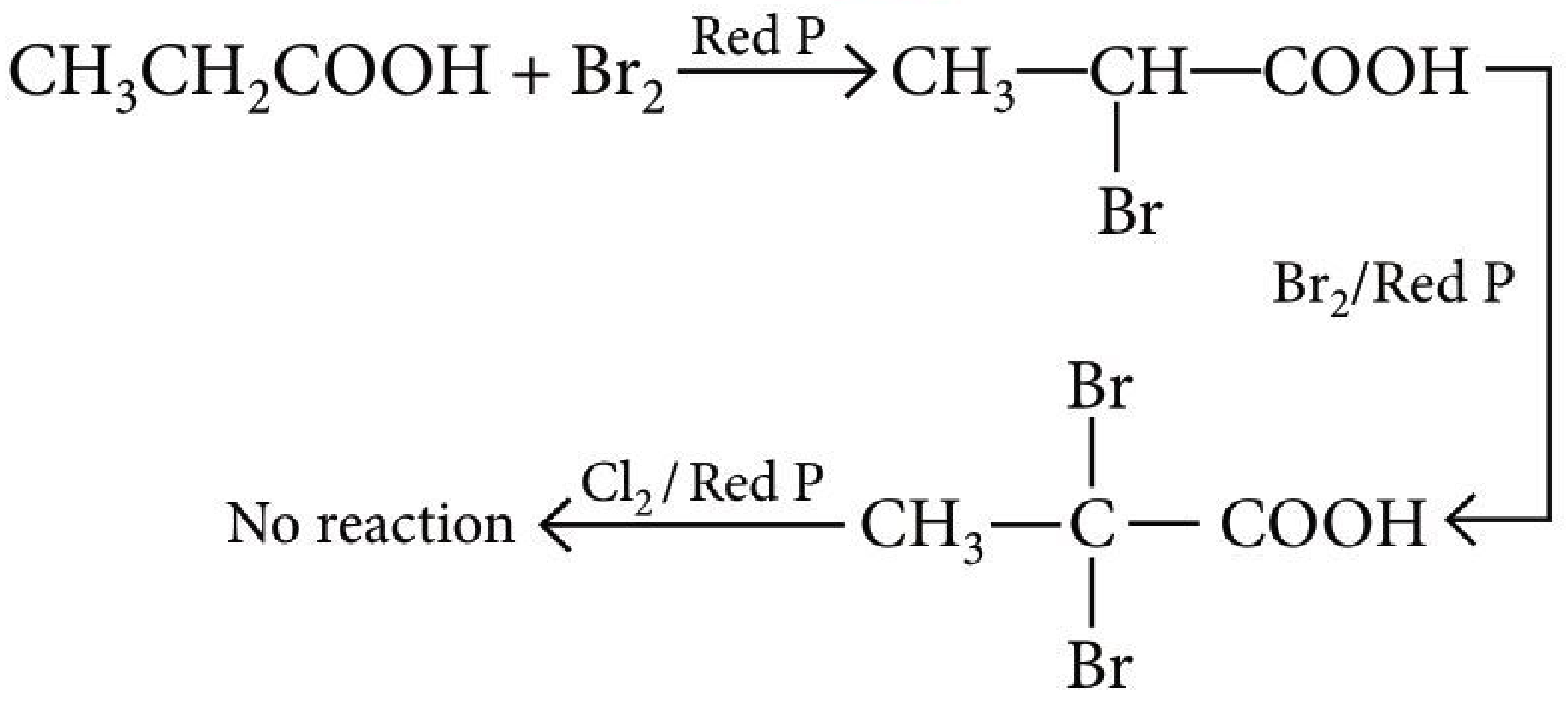
When primary alcohols are oxidised by $KMnO_4$, then carboxylic acid is formed.

32. (i) As there is no α-hydrogen present in $(CH_3)_3CCOOH$, So it does not undergo HVZ reaction.

(ii) Red P combine with I_2 to give PI_3. As PI_3 is much less stable then PCl_3 and PBr_3, So, α-iodo product do not formed.

(iii) Red phosphorus reacts with bromine to give phosphorous tribromide which acts as catalyst for the reaction.

OR



$$CH_3CH_2COOH + Br_2 \xrightarrow{\text{Red P}} CH_3-\underset{\underset{Br}{|}}{CH}-COOH \xrightarrow{Br_2/\text{Red P}} CH_3-\underset{\underset{Br}{|}}{\overset{\overset{Br}{|}}{C}}-COOH \xrightarrow{Cl_2/\text{Red P}} \text{No reaction}$$

(As there is no α-hydrogen left so, further reaction does not proceed.)

33. (i) Tollens' reagent test.

$$\underset{\text{Acetaldehyde}}{CH_3CHO} + 2[Ag(NH_3)_2]^{2+} \xrightarrow{3OH^-} CH_3COO^- + 2Ag\downarrow + 2H_2O + 4NH_3$$

$$\underset{\text{Propanone}}{CH_3COCH_3} \xrightarrow[\text{reagent}]{\text{Tollens'}} \text{No reaction}$$

(ii) Tollens' reagent test.

$$\underset{\text{Formaldehyde}}{HCHO} \xrightarrow{\text{Tollens' reagent}} HCOOH + \underset{\text{Silver mirror}}{Ag\downarrow}$$

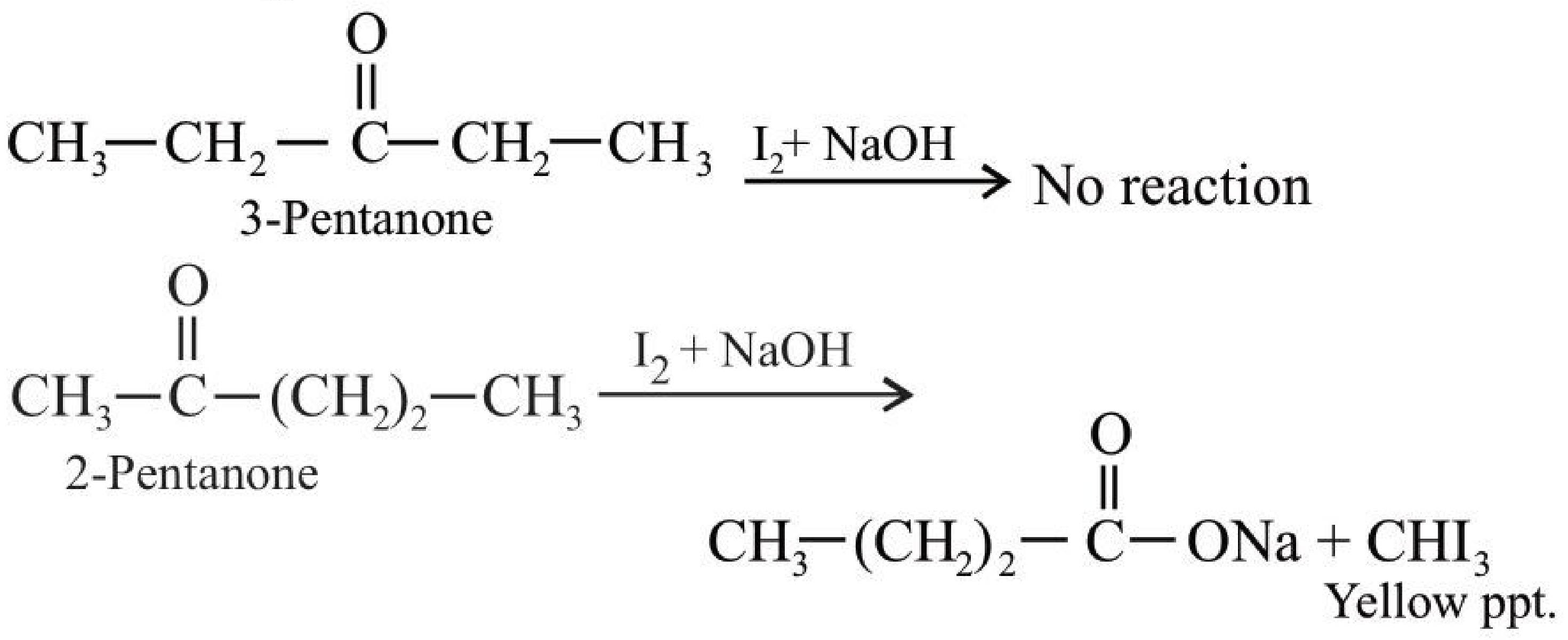
$$\underset{\text{Acetone}}{CH_3COCH_3} \xrightarrow{\text{Tollens' reagent}} \text{No reaction}$$

(iii) Tollens' reagent test.

$$\underset{\text{Ethyl alcohol}}{CH_3CH_2OH} \xrightarrow{\text{Tollens' reagent}} \text{No reaction}$$

$$\underset{\text{Acetaldehyde}}{CH_3CHO} \xrightarrow{\text{Tollens' reagent}} \text{Silver mirror} + CH_3COO^-$$

(iv) 2-Pentanone gives iodoform test but 3-pentanone does not give such test.



$$\underset{\text{3-Pentanone}}{CH_3-CH_2-\overset{\overset{O}{\|}}{C}-CH_2-CH_3} \xrightarrow{I_2 + NaOH} \text{No reaction}$$

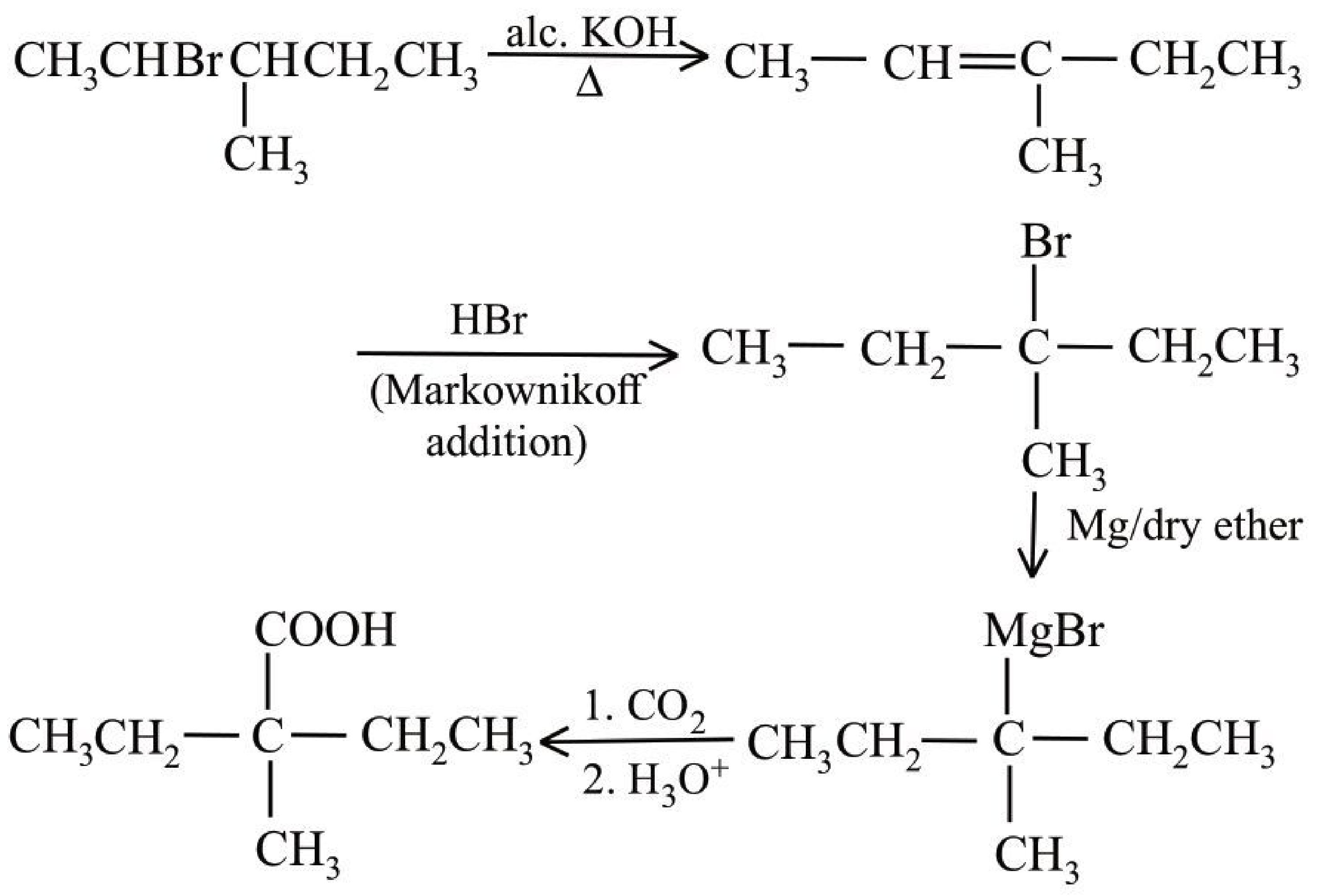
$$\underset{\text{2-Pentanone}}{CH_3-\overset{\overset{O}{\|}}{C}-(CH_2)_2-CH_3} \xrightarrow{I_2 + NaOH} CH_3-(CH_2)_2-\overset{\overset{O}{\|}}{C}-ONa + \underset{\text{Yellow ppt.}}{CHI_3}$$

(v) $\underset{\text{Propanol}}{CH_3CH_2CH_2OH} \xrightarrow{I_2 + NaOH} \text{No reaction}$

$\underset{\text{Propanone}}{CH_3COCH_3} \xrightarrow{I_2 + NaOH} CH_3COONa + \underset{\text{Iodoform}}{CHI_3}$

OR

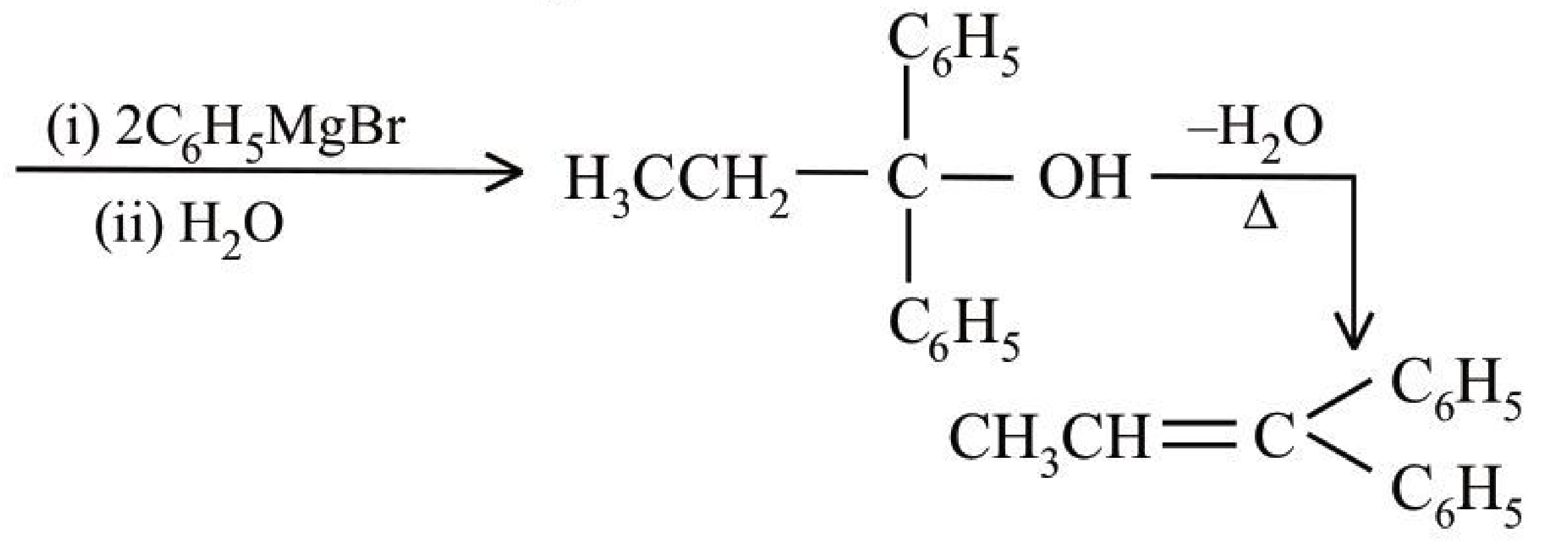
(a)



$CH_3CHBr\underset{\substack{|\\CH_3}}{CH}CH_2CH_3 \xrightarrow[\Delta]{\text{alc. KOH}} CH_3-CH=\underset{\substack{|\\CH_3}}{C}-CH_2CH_3 \xrightarrow[\text{(Markownikoff addition)}]{HBr} CH_3-CH_2-\overset{\substack{Br\\|}}{\underset{\substack{|\\CH_3}}{C}}-CH_2CH_3$

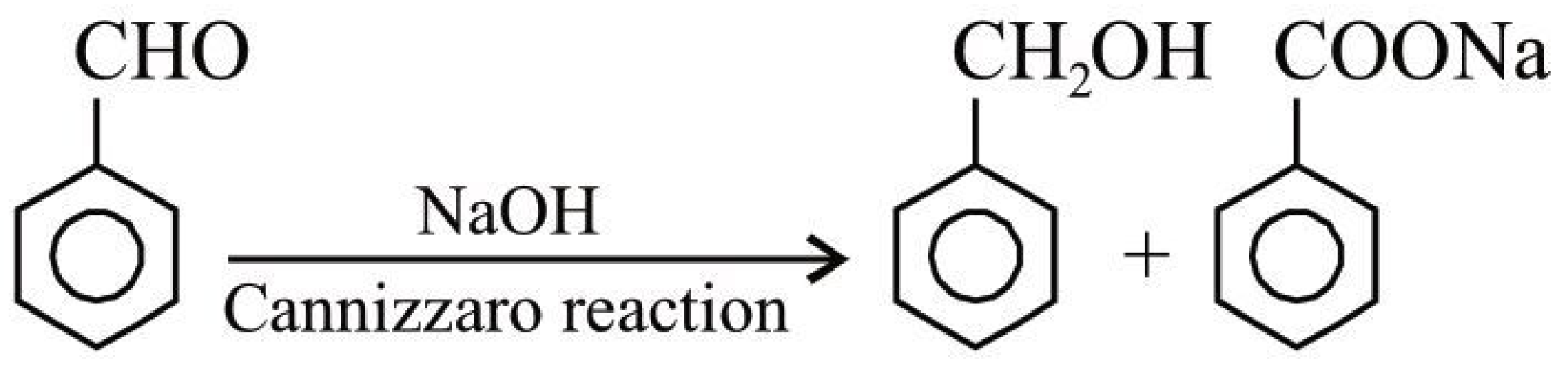
$\xrightarrow{\text{Mg/dry ether}} CH_3CH_2-\overset{\substack{MgBr\\|}}{\underset{\substack{|\\CH_3}}{C}}-CH_2CH_3 \xrightarrow[2.\ H_3O^+]{1.\ CO_2} CH_3CH_2-\overset{\substack{COOH\\|}}{\underset{\substack{|\\CH_3}}{C}}-CH_2CH_3$

(b) $CH_3CH_2COOH \xrightarrow[H^+]{C_2H_5OH} CH_3CH_2COOC_2H_5$

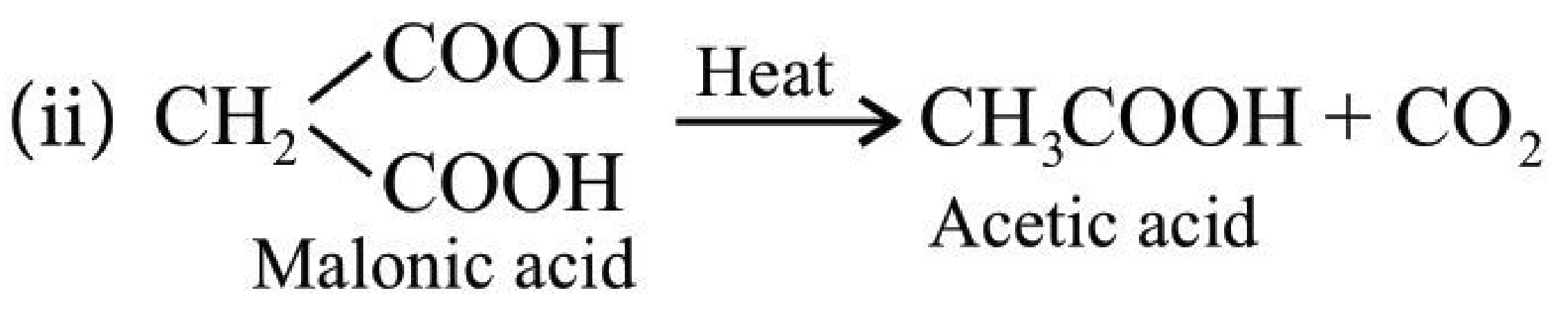


$\xrightarrow[\text{(ii) }H_2O]{\text{(i) }2C_6H_5MgBr} H_3CCH_2-\overset{\substack{C_6H_5\\|}}{\underset{\substack{|\\C_6H_5}}{C}}-OH \xrightarrow[\Delta]{-H_2O} CH_3CH=C\begin{smallmatrix}C_6H_5\\C_6H_5\end{smallmatrix}$

34. (a) (i)

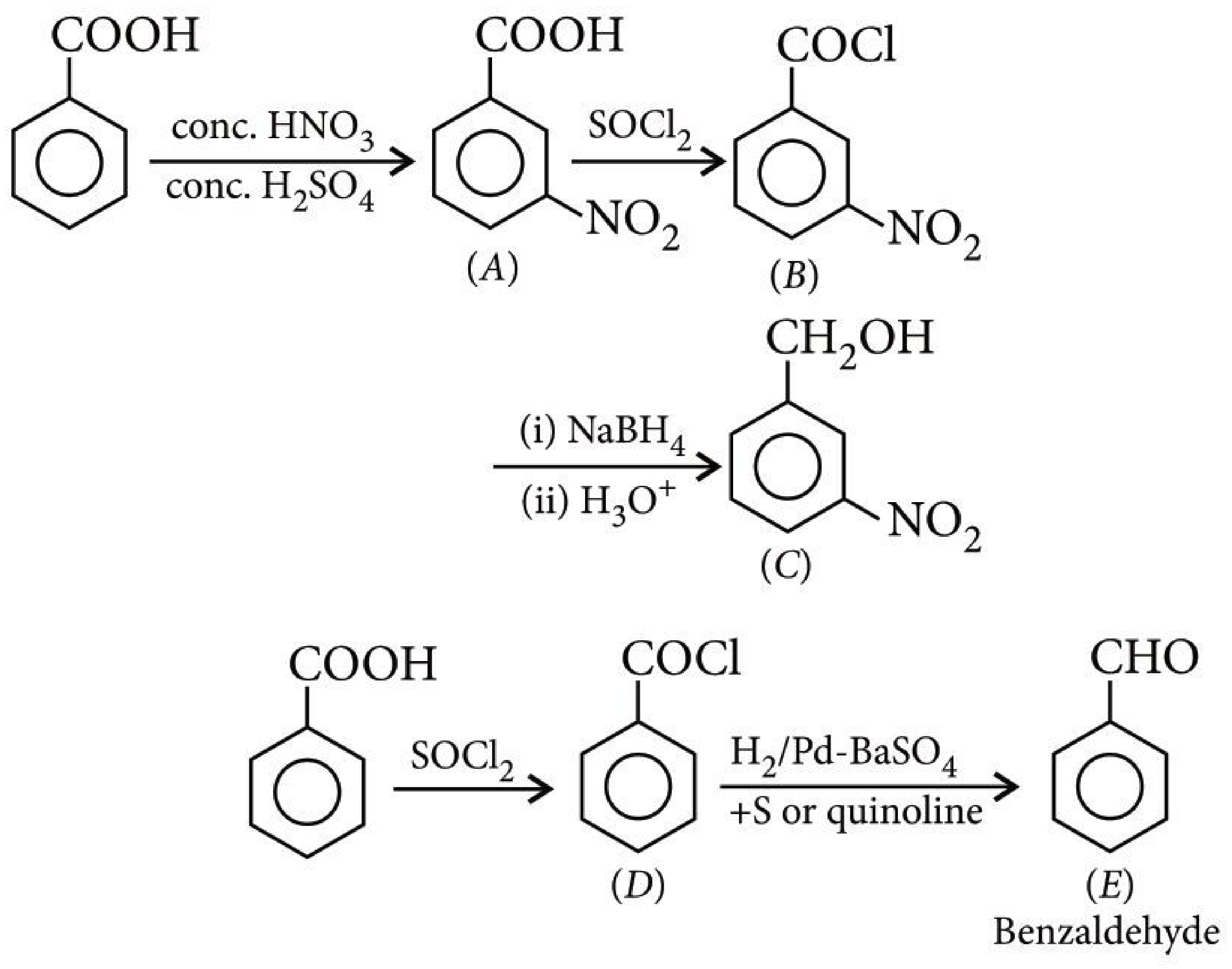

CHO
NaOH
Cannizzaro reaction
CH2OH
COONa
+

(ii)



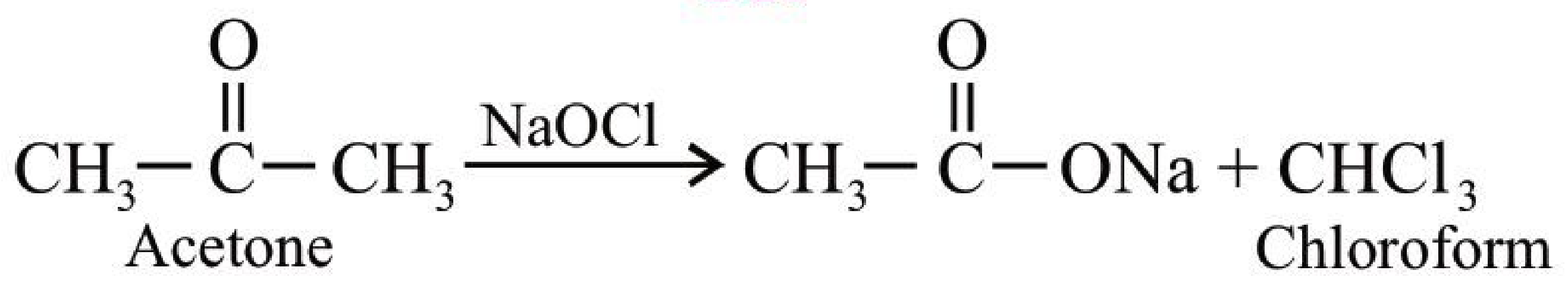
$\underset{\text{Malonic acid}}{CH_2\begin{smallmatrix}COOH\\COOH\end{smallmatrix}} \xrightarrow{\text{Heat}} \underset{\text{Acetic acid}}{CH_3COOH} + CO_2$

(b)


COOH
conc. HNO3
conc. H2SO4
COOH
NO2
(A)
SOCl2
COCl
NO2
(B)
(i) NaBH4
(ii) H3O+
CH2OH
NO2
(C)
COOH
SOCl2
COCl
(D)
H2/Pd-BaSO4
+S or quinoline
CHO
(E)
Benzaldehyde

OR

(i)

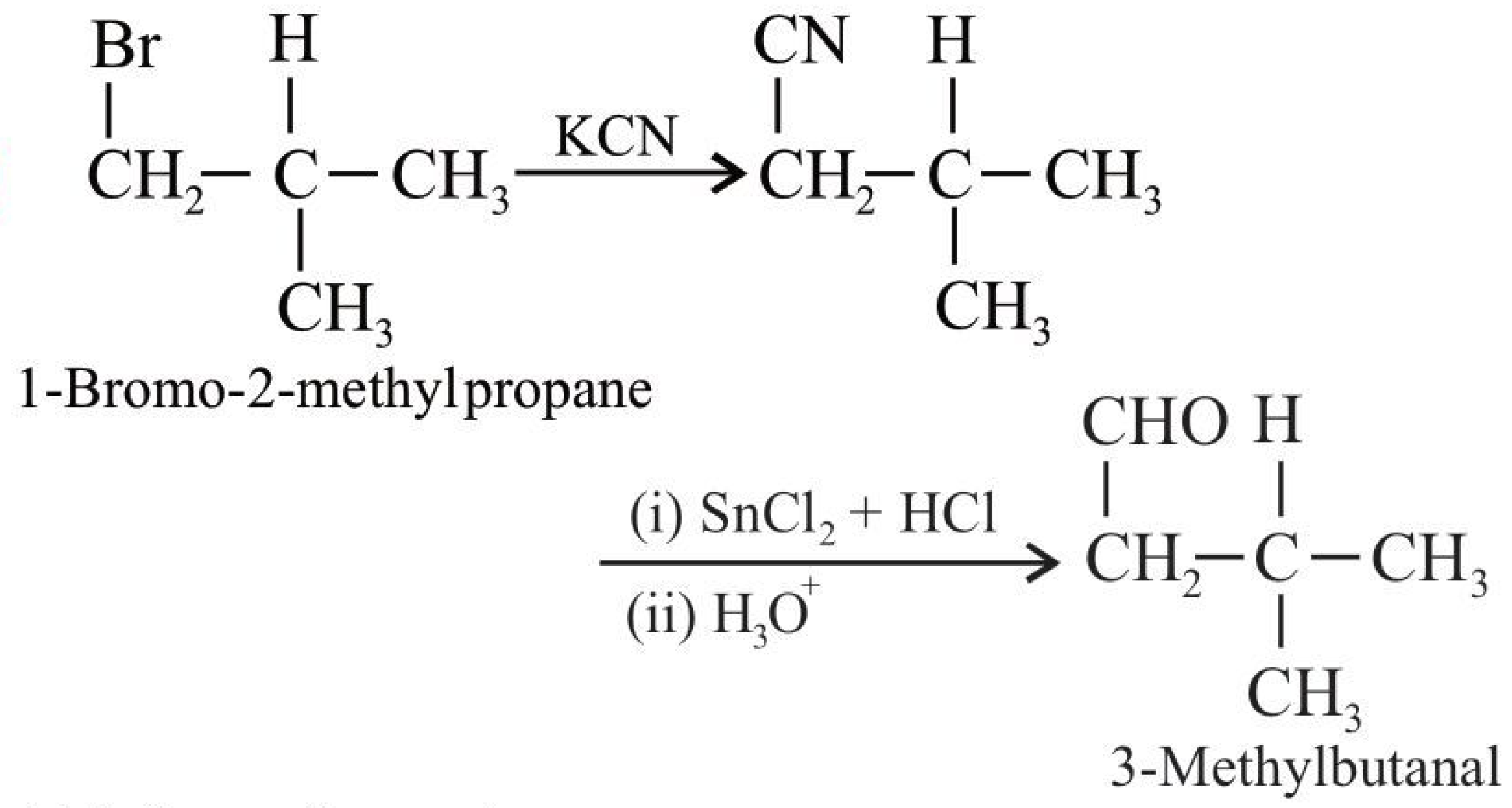


$\underset{\text{Acetone}}{CH_3-\overset{\substack{O\\||}}{C}-CH_3} \xrightarrow{NaOCl} CH_3-\overset{\substack{O\\||}}{C}-ONa + \underset{\text{Chloroform}}{CHCl_3}$

(ii) $\underset{\text{Acetylene}}{CH\equiv CH} + H_2O \xrightarrow[333\text{ K}]{\text{dil. }H_2SO_4 + HgSO_4} CH_2=CH-OH$

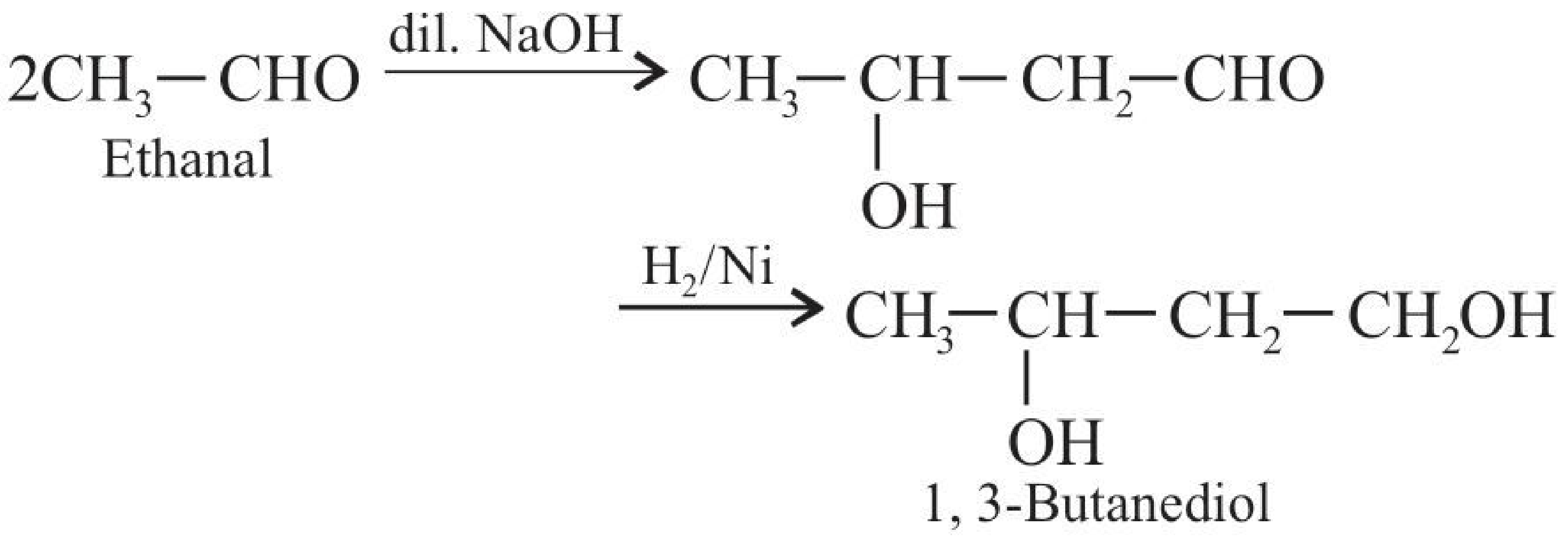
$\xrightarrow{\text{Isomerise}} CH_3-CHO \xrightarrow{[O]} \underset{\text{Acetic acid}}{CH_3COOH}$

(iii)



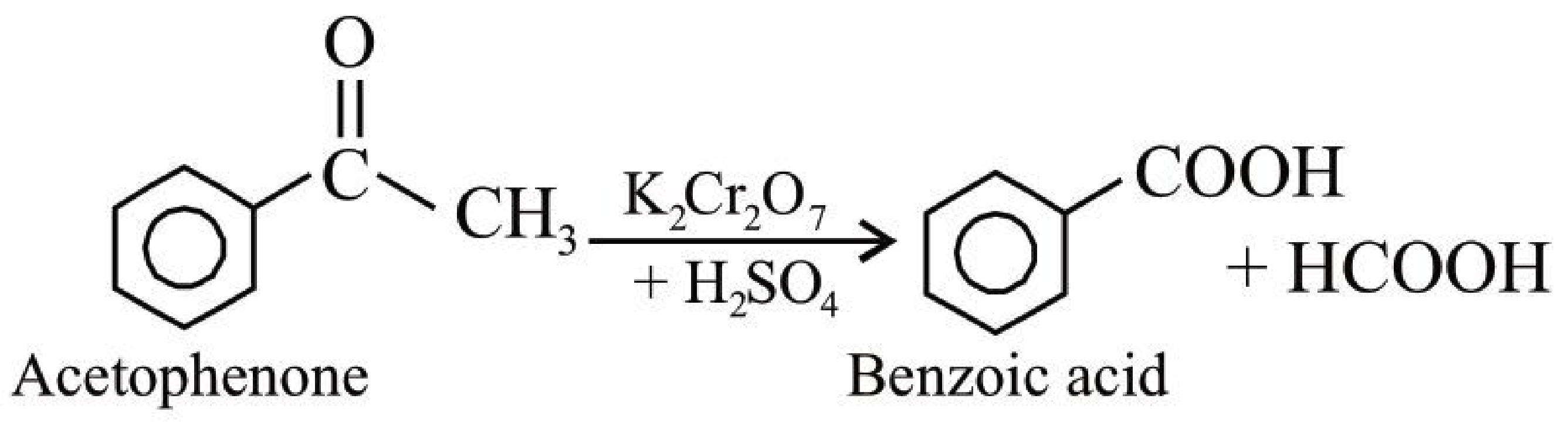
$\underset{\text{1-Bromo-2-methylpropane}}{\overset{\substack{Br\\|}}{CH_2}-\overset{\substack{H\\|}}{\underset{\substack{|\\CH_3}}{C}}-CH_3} \xrightarrow{KCN} \overset{\substack{CN\\|}}{CH_2}-\overset{\substack{H\\|}}{\underset{\substack{|\\CH_3}}{C}}-CH_3 \xrightarrow[\text{(ii) }H_3O^+]{\text{(i) }SnCl_2 + HCl} \underset{\text{3-Methylbutanal}}{\overset{\substack{CHO\\|}}{CH_2}-\overset{\substack{H\\|}}{\underset{\substack{|\\CH_3}}{C}}-CH_3}$

(iv) Aldol condensation

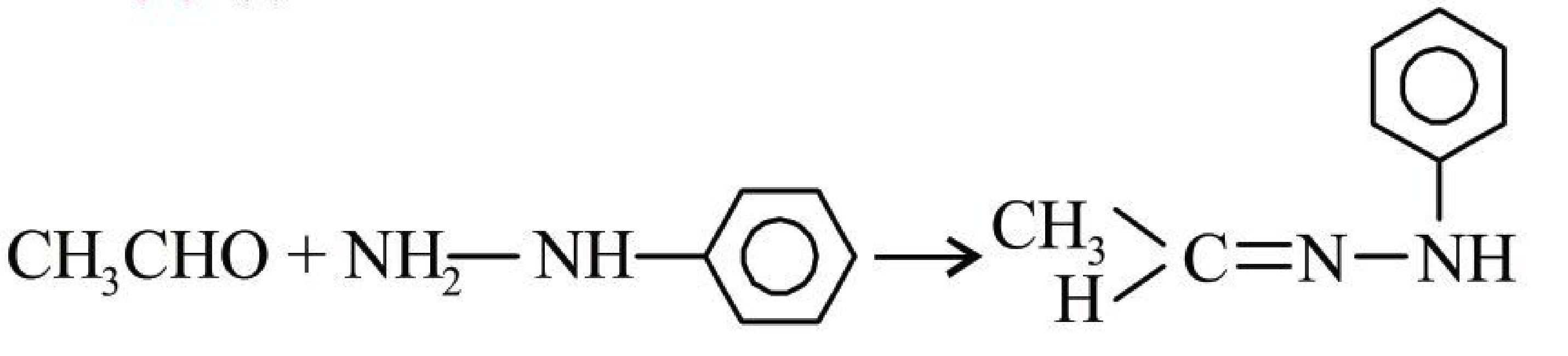


$\underset{\text{Ethanal}}{2CH_3-CHO} \xrightarrow{\text{dil. NaOH}} CH_3-\underset{\substack{|\\OH}}{CH}-CH_2-CHO \xrightarrow{H_2/Ni} \underset{\text{1, 3-Butanediol}}{CH_3-\underset{\substack{|\\OH}}{CH}-CH_2-CH_2OH}$

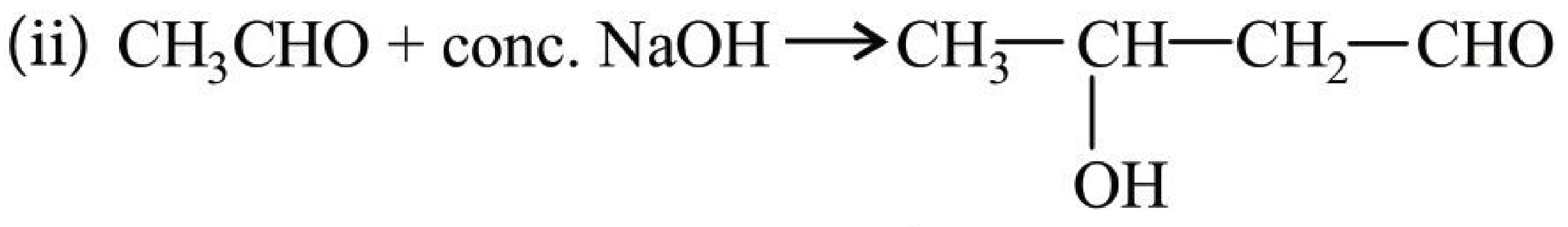
(v)


O
C
CH3
Acetophenone
K2Cr2O7
+ H2SO4
COOH
+ HCOOH
Benzoic acid

35. (a) (i)


CH3CHO + NH2—NH—
CH3
H
C=N—NH

(ii)



$CH_3CHO + \text{conc. NaOH} \rightarrow CH_3-\underset{\substack{|\\OH}}{CH}-CH_2-CHO$

(iii) $CH_3CHO + Zn\text{–}Hg \xrightarrow{\text{Conc. HCl}} CH_3CH_3$

(b) (i) Ester of carboxylic acid on treatment with phenol or alcohol in the presence of mineral acid as a catalyst gives another ester. This reaction is called *trans*-esterification reaction.

(ii) Tollens' reagent is ammoniacal silver nitrate solution which gives a bright silver mirror when warmed with an aldehyde.

$$RCHO + 2[Ag(NH_3)_2]^+ + 3OH^- \longrightarrow RCOO^- + 2Ag + 2H_2O + 4NH_3$$

◆

MONTHLY TEST DRIVE

XII

This specially designed column enables students to self analyse their extent of understanding the specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Total Marks : 120

Electrochemistry | Chemical Kinetics

Time Taken : 60 Min.

NEET

Only One Option Correct Type

1. Specific conductance of 0.1 M nitric acid is 6.3×10^{-2} ohm^{-1} cm^{-1}. The molar conductance of the solution is

(a) 630 ohm^{-1} cm^{2} mol^{-1}
(b) 315 ohm^{-1} cm^{2} mol^{-1}
(c) 6.300 ohm^{-1} cm^{2} mol^{-1}
(d) 63.0 ohm^{-1} cm^{2} mol^{-1}

2. If 50% of the reactant is converted into a product in a first order reaction in 25 minutes, how much of it would react in 100 minutes?

(a) 93.75% (b) 87.5% (c) 75% (d) 100%

3. For which of the following order of reaction, half-life is independent of initial concentration?

(a) 1st order (b) Zero order
(c) 3rd order (d) 2nd order

4. On passing 5 ampere current through an aqueous solution of an unknown salt of Pd for 2.15 hours, 10.64 g of Pd^{n+} get deposited at cathode. The value of n is (At. wt. of Pd = 106.4)

(a) 2 (b) 3 (c) 3.5 (d) 4

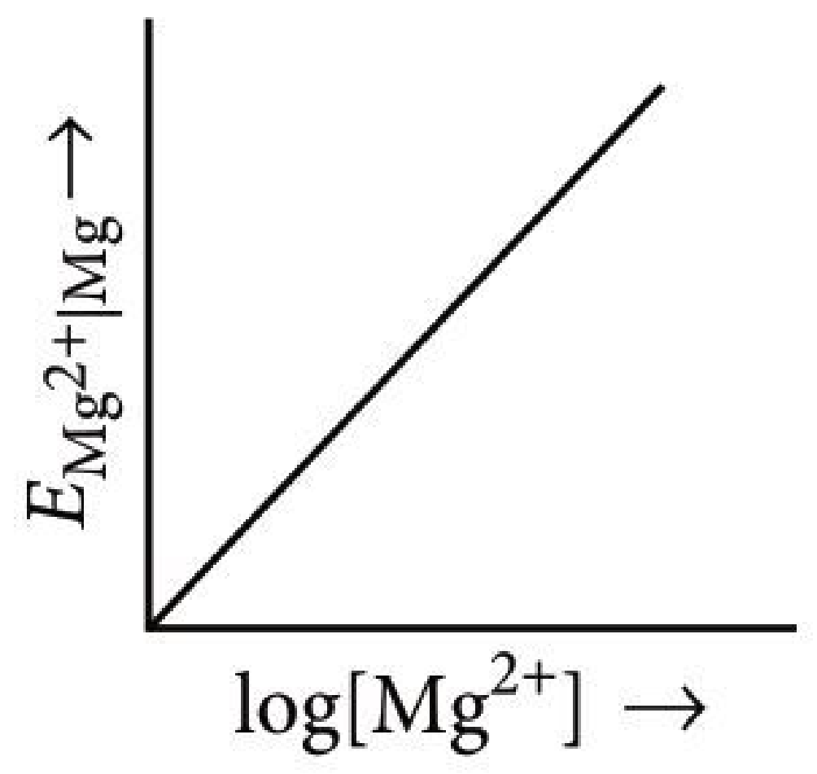
5. Acid catalysed hydrolysis of ethyl acetate follows a pseudo-first order kinetics with respect to ester. If the reaction is carried out with large excess of ester, the order with respect to ester will be

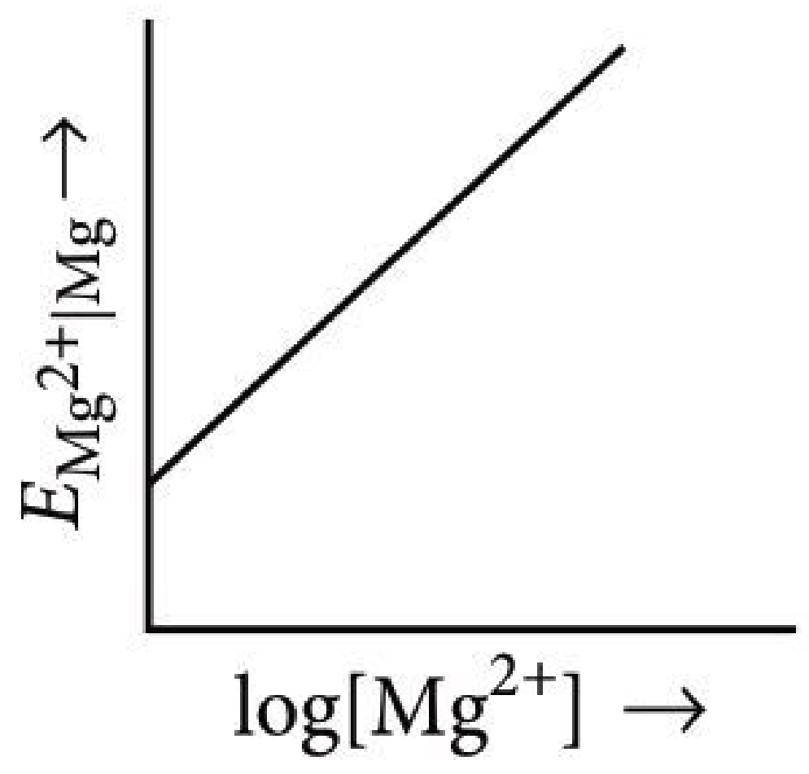
(a) 1.5 (b) 0 (c) 2 (d) 1

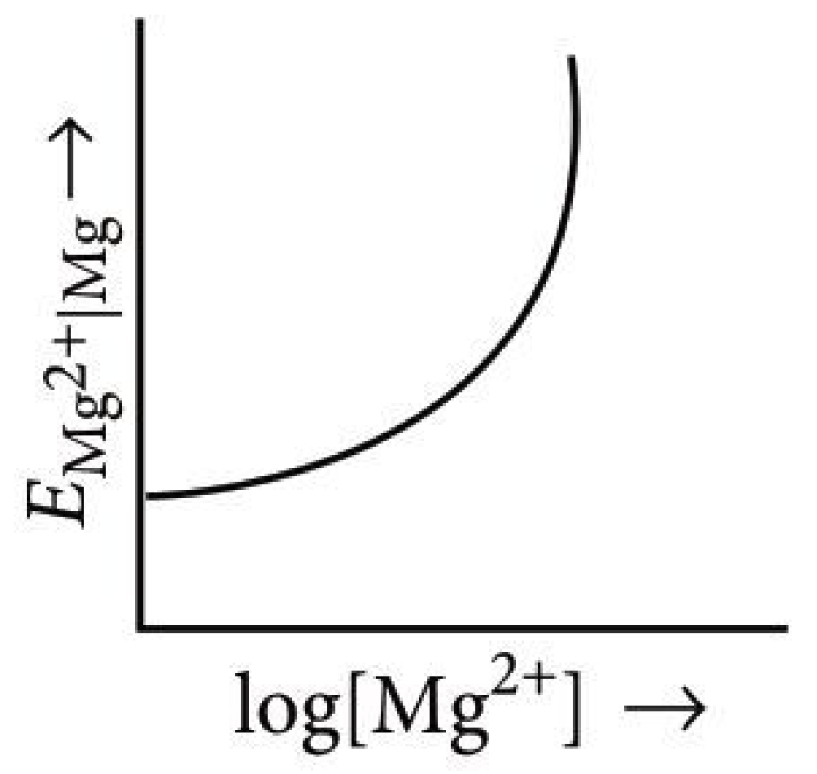
6. Electrode potential for Mg electrode varies according to the equation

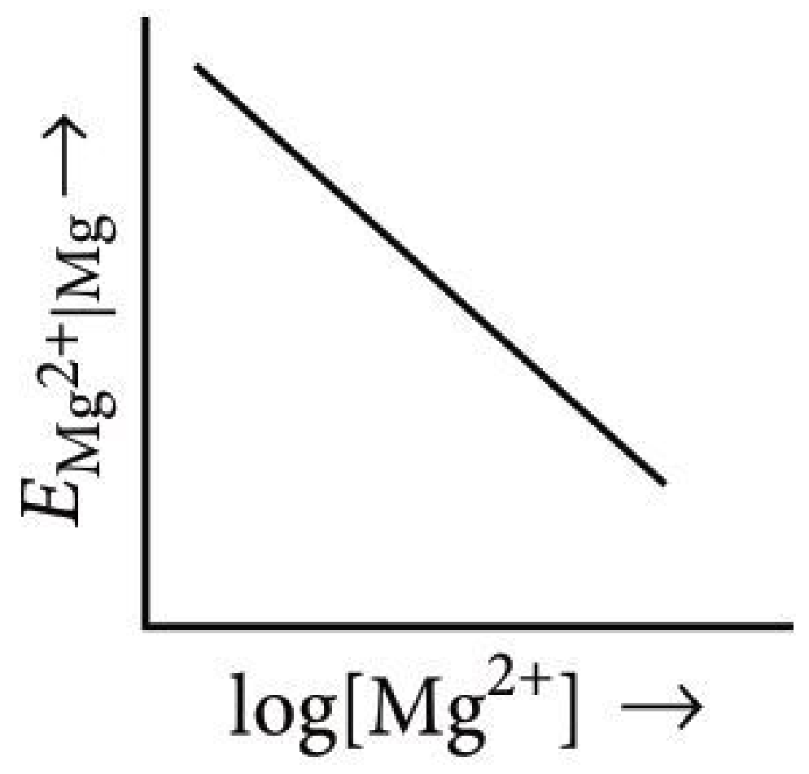
$$E_{Mg^{2+}/Mg} = E^{o}_{Mg^{2+}/Mg} - \frac{0.059}{2}\log\frac{1}{[Mg^{2+}]}$$

The graph of $E_{Mg^{2+}|Mg}$ *vs* log $[Mg^{2+}]$ is

(a)


(b)


(c)


(d)


7. Consider the following statements :

(i) increase in concentration of reactant increases the rate of a zero order reaction.
(ii) rate constant k is equal to collision frequency A if $E_a = 0$.
(iii) rate constant k is equal to collision frequency A if $E_a = \infty$.
(iv) ln k *vs* T is a straight line.
(v) ln k *vs* $1/T$ is a straight line.

Correct statements are

(a) (i) and (iv) (b) (ii) and (v)
(c) (iii) and (iv) (d) (ii) and (iii)

8. Which of the substances Na, Hg, S, Pt and graphite can be used as electrodes in electrolytic cells having aqueous solutions?

(a) Na, Pt and graphite
(b) Na and Hg
(c) Pt and graphite only
(d) Na and S only

9. The activation energy of a chemical reaction can be determined by

(a) evaluating rate constants at two different temperatures

(b) changing the concentration of reactants

(c) evaluating the concentration of reactants at two different temperatures

(d) evaluating rate constant at standard temperature.

10. Which of the following is an incorrect relation?

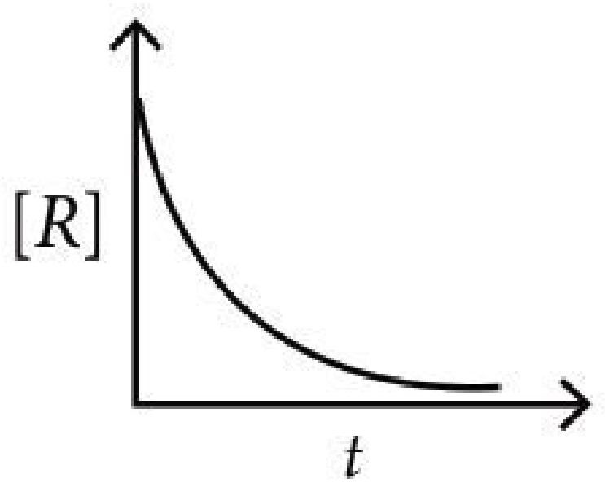
(a) $E_a = -2.303 \times R \times \text{slope}$

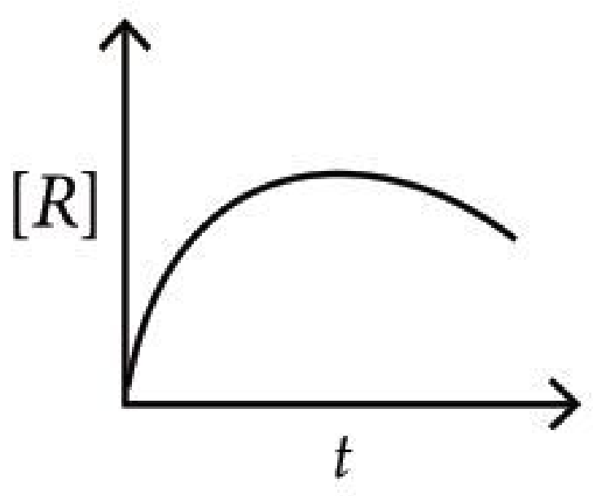
(b) $k = Ae^{-E_a/RT}$

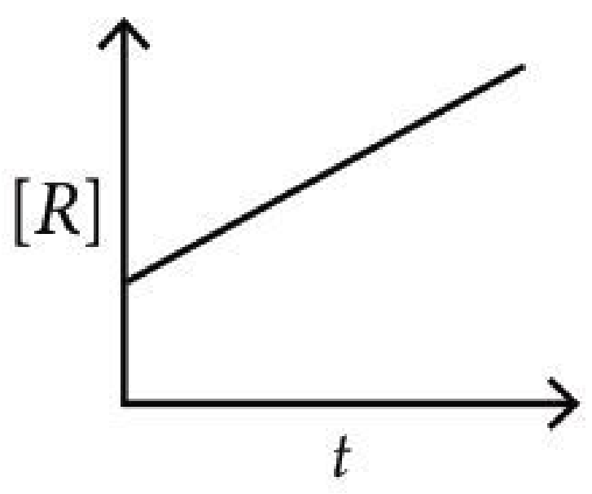
(c) $k = e^{-RT}$

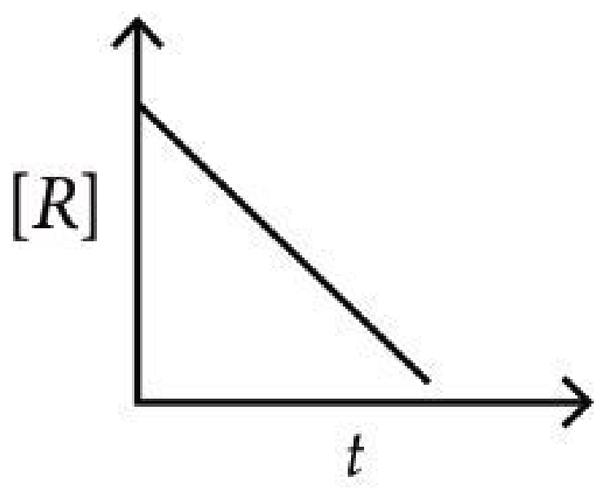
(d) $f = e^{-E_a/RT}$

11. The plot of concentration of the reactant versus time for a zero order reaction is given by

(a)


(b)


(c)


(d)


12. What will be the emf for the given cell?

$Pt|H_2(g, P_1) \mid H^+_{(aq)} \mid H_2(g, P_2) \mid Pt$

(a) $\frac{RT}{F}\ln\frac{P_1}{P_2}$

(b) $\frac{RT}{2F}\ln\frac{P_1}{P_2}$

(c) $\frac{RT}{F}\ln\frac{P_2}{P_1}$

(d) $\frac{RT}{2F}\ln\frac{P_2}{P_1}$

Assertion & Reason Type

Directions : In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :

(a) If both assertion and reason are true and reason is the correct explanation of assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of assertion.

(c) If assertion is true but reason is false.

(d) If both assertion and reason are false.

13. **Assertion :** Two different reactions can never have same rate of reaction.

Reason : Rate of reaction always depends only on frequency of collision and Arrhenius factor.

14. **Assertion :** Reverse current flows in charging of lead storage battery.

Reason : During charging, $PbSO_4$ converts into Pb and PbO_2.

15. **Assertion :** Half-life period of a reaction of first order is independent of initial concentration.

Reason : Half-life period for a first order reaction, $t_{1/2} = \frac{2.303}{k}\log 2$.

PUBLIC NOTICE

WBJEE 2023

The West Bengal Joint Entrance Examinations Board (WBJEEB) will conduct OMR based Common Entrance Examination WBJEE-2023 for admission in the academic session 2023-24 for Undergraduate Courses in Engineering/Technology, Pharmacy and Architecture of different Universities, Government Colleges as well as Self-Financing Engineering/Technological Institutes in the State of West Bengal.

Schedule of WBJEE-2023

Date of Examination	Paper/Subject	Time schedule
30/04/2023 **(Sunday)** (Tentative and may be changed in extra ordinary circumstances)	Paper-I (Mathematics)	11:00 a.m. to 1.00 p.m.
	Paper-II (Physics & Chemistry)	2:00 p.m. to 4:00 p.m.

The test will be held once in a year and there shall be no further examination under any circumstances for those who are unable to appear on the date and time mentioned above.

Pattern of Question Papers in WBJEE-2023

All questions will be **Multiple-Choice Questions (MCQ)**, with four options against each question. There will be three categories of questions in each subject. The number of questions as well as maximum marks for each are given in the following table:

Subject	**Category-1** Each Q carries 1 mark (–ve marks = –1/4)	**Category-2** Each Q carries 2 marks (–ve marks = –1/2)	**Category-3** Each Q carries 2 marks (No –ve marks)	Total Number of Questions	**Total Marks**
	No. of Q	No. of Q	No. of Q		
Mathematics	50	15	10	75	100
Physics	30	5	5	40	50
Chemistry	30	5	5	40	50

For more information, please visit the official website www.wbjeeb.nic.in

JEE MAIN / JEE ADVANCED

Only One Option Correct Type

16. The rate of a certain biochemical reaction at physiological temperature (T) occurs 10^6 times faster with enzyme than without. The change in the activation energy upon adding enzyme is

(a) $-6RT$ (b) $-6(2.303)RT$

(c) $+6RT$ (d) $+6(2.303)RT$.

17. The following facts are available

$2A^- + B_2 \rightarrow 2B^- + A_2$

$2C^- + B_2 \rightarrow$ No reaction

$2D^- + A_2 \rightarrow 2A^- + D_2$

Which of the following statement is correct?

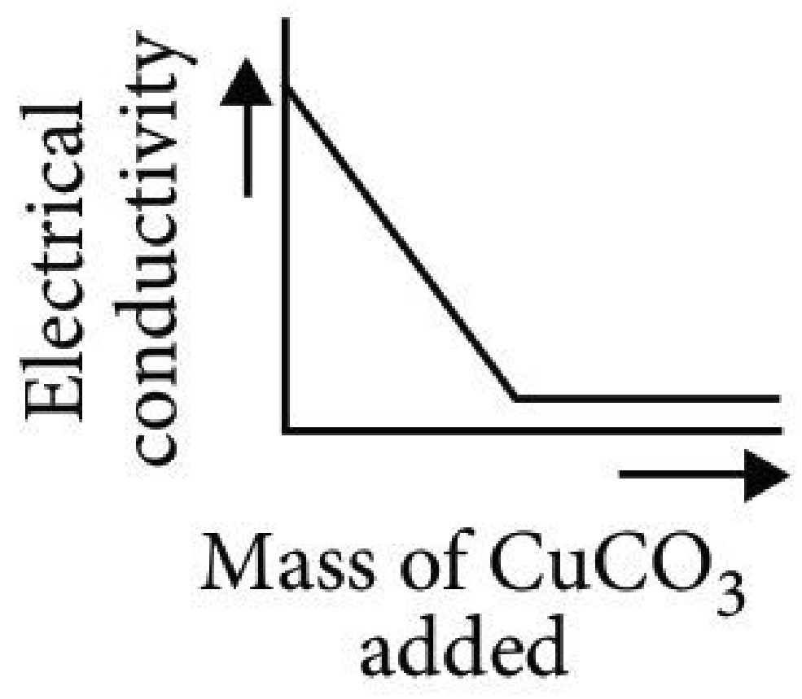
(a) $E^o_{C^-/C_2} > E^o_{B^-/B_2} > E^o_{A^-/A_2} > E^o_{D^-/D_2}$

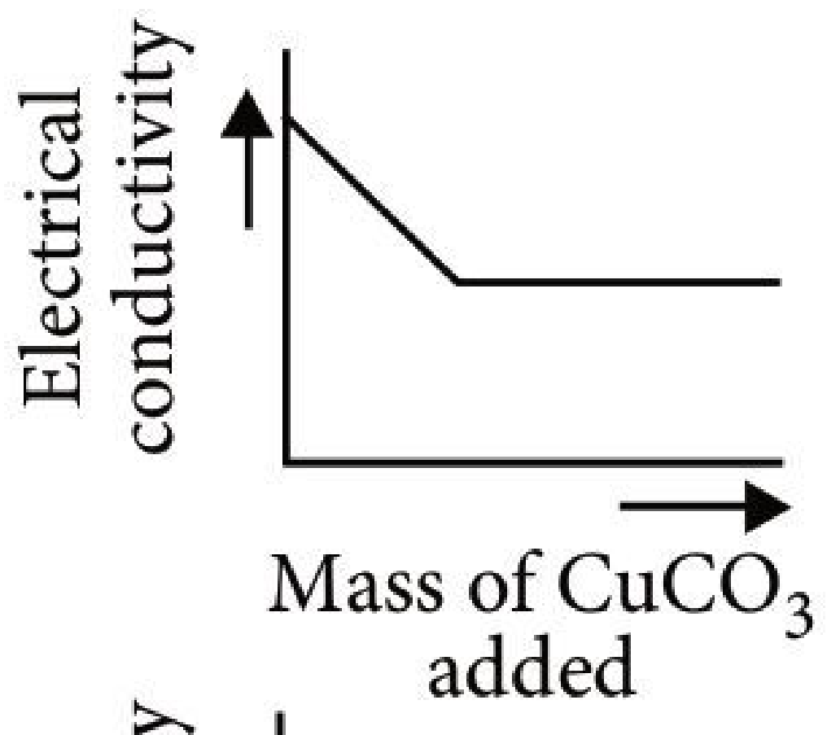
(b) $E^o_{C^-/C_2} < E^o_{B^-/B_2} < E^o_{A^-/A_2} < E^o_{D^-/D_2}$

(c) $E^o_{C^-/C_2} < E^o_{B^-/B_2} > E^o_{A^-/A_2} > E^o_{D^-/D_2}$

(d) $E^o_{C^-/C_2} > E^o_{B^-/B_2} < E^o_{A^-/A_2} < E^o_{D^-/D_2}$.

18. Which one of the following graphs correctly represents the change in electrical conductivity as copper (II) carbonate is gradually added to dilute sulphuric acid?

(a)


(b)


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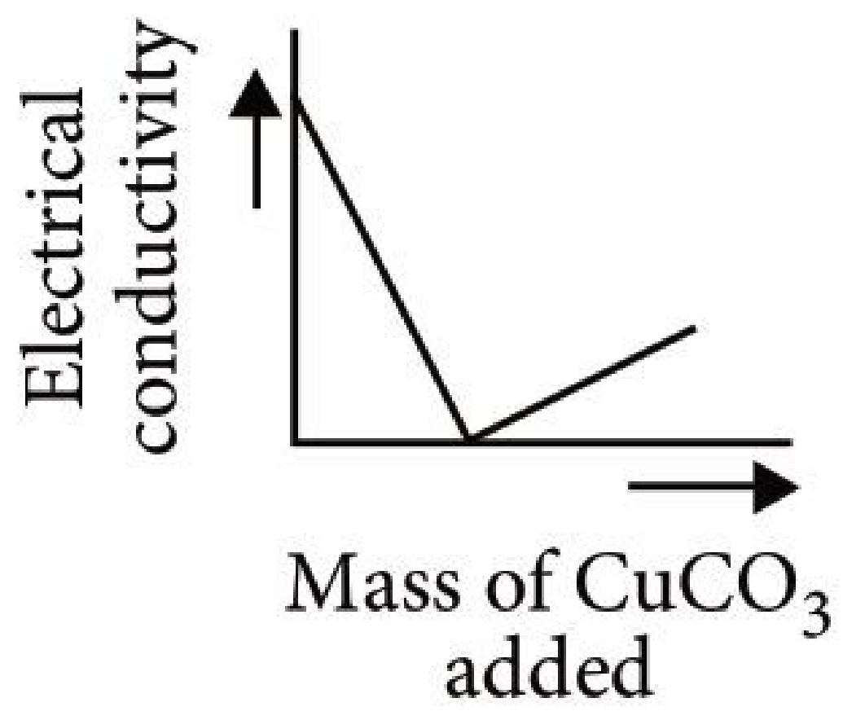

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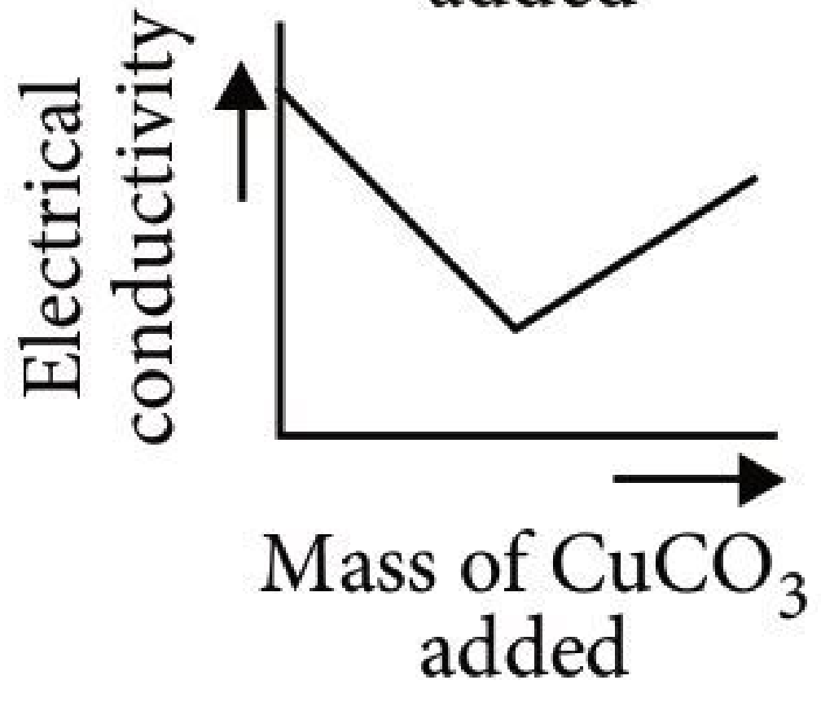
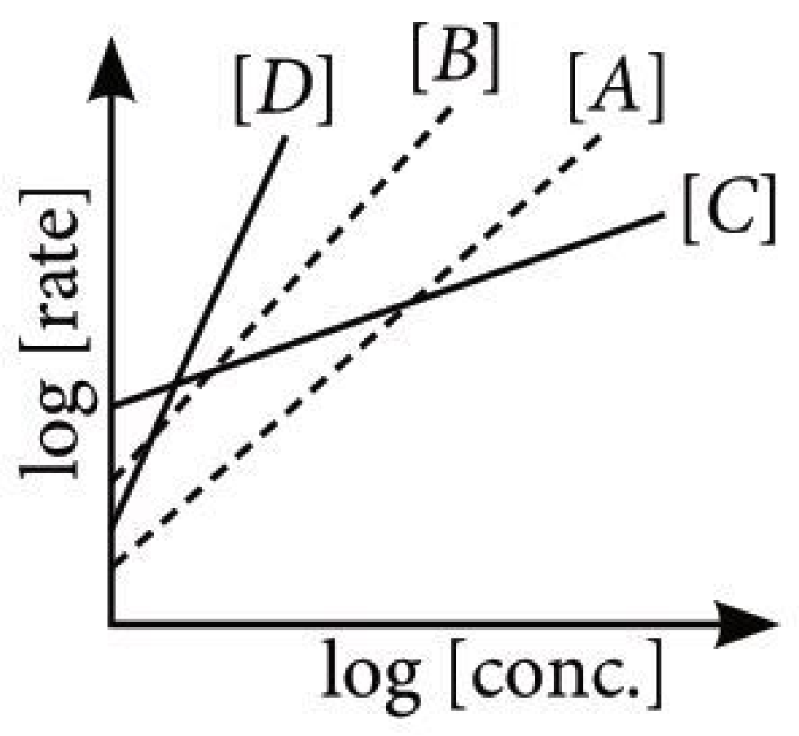


19. Consider the following reactions :

$A \rightarrow P_1 ; B \rightarrow P_2 ; C \rightarrow P_3 ; D \rightarrow P_4$,

The orders of the above reactions are a, b, c and d respectively. The following graph is obtained when log[rate] *vs.* log[conc.] are plotted :



Among the following, the correct sequence for the order of the reactions is

(a) $d > a > b > c$ (b) $a > b > c > d$

(c) $c > a > b > d$ (d) $d > b > a > c$

More than One Option Correct Type

20. The salt-bridge in a galvanic cell

(a) completes the electrical circuit

(b) separates both the solutions from each other

(c) maintains electrical neutrality

(d) maintains standard electrode potential of cell constant which depends on several factors

21. Which of the following is/are correct regarding activation energy?

(a) Larger the activation energy, smaller is the value of rate constant

(b) The higher the E_a, higher the value of temperature coefficient, $\frac{k_T + 10}{k_T}$

(c) At lower temperature, increase in temperature causes more change in the value of k than at higher temperature.

(d) A plot made between ln k and $1/T$ gives a straight line of slope $-\frac{E_a}{R}$

22. For a first order reaction,

(a) the degree of dissociation is equal to $(1 - e^{-kt})$

(b) a plot of reciprocal concentration of the reactant vs time gives a straight line

(c) the time taken for the completion of 75% reaction is thrice the $t_{1/2}$ of the reaction

(d) the pre-exponential factor in the Arrhenius equation has the dimension of time, T^{-1}.

23. For the reduction of NO_3^- ion in an aqueous solution, $E°$ is +0.96 V. Values of $E°$ for some metal ions are given below :

$V^{2+}_{(aq)} + 2e^- \rightarrow V;\ E° = -1.19$ V

$Fe^{3+}_{(aq)} + 3e^- \rightarrow Fe;\ E° = -0.04$ V

$Au^{3+}_{(aq)} + 3e^- \rightarrow Au;\ E° = +1.40$ V

$Hg^{2+}_{(aq)} + 2e^- \rightarrow Hg;\ E° = +0.86$ V

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3-a-	COLLOID	4-i-	PYROLYSIS
5-d-	INSULATOR	6-b-	EMULSIFIER
7-g-	POSITRON	8-j-	UREASE
9-e-	MOLARITY	10-h-	SEABORGIUM

Winners : *Kaushikkumar Kevadiya, Ojasv Chauhan*

The pair(s) of metals that is(are) oxidised by NO_3^- in aqueous solution is(are)

(a) V and Hg (b) Hg and Fe
(c) Fe and Au (d) Fe and V.

Integer / Numerical Value Type

24. The mass of carbon anode consumed (giving only carbon dioxide) in production of 270 kg of aluminium metal from bauxite by the Hall process is _______ kg.

25. The following data were obtained during the first order decomposition of $2A_{(g)} \longrightarrow B_{(g)} + C_{(s)}$ at a constant volume and at a particular temperature.

S. No.	Time	Total pressure in pascal
1	At the end of 10 min	300
2	After completion	200

The rate constant in (min^{-1}) is _________.

26. The Gibbs energy change (in J) for the given reaction $Cu_{(s)} + Sn^{2+}_{(aq.)} \longrightarrow Cu^{2+}_{(aq.)} + Sn_{(s)}$; at $[Cu^{2+}] = [Sn^{2+}] = 1$ M and 298 K is _______.
($E^\circ_{Sn^{2+}/Sn} = -0.16$ V, $E^\circ_{Cu^{2+}/Cu} = 0.34$ V,
Take $F = 96500$ C mol^{-1})

Comprehension Type Questions

At 600°C, acetone (CH_3COCH_3) decomposes to ketene ($CH_2{=}C{=}O$) and various hydrocarbons. Initial rate data are given in the table below:

Experiment	Initial $[CH_3COCH_3]$	Initial rate of consumption of acetone (M/s)
1	6.0×10^{-3}	5.2×10^{-5}
2	9.0×10^{-3}	7.8×10^{-5}.

27. The rate constant for the decomposition reaction is

(a) 8.7×10^{-3} s^{-1} (b) 6.12×10^{-5} s^{-1}
(c) 2.8×10^{-3} s^{-1} (d) 1.10×10^{-3} s^{-1}

28. Which of the following is the rate of decomposition when the [acetone] is 1.8×10^{-3} M?

(a) 1×10^{-5} M/s (b) 1.6×10^{-5} M/s
(c) 2.7×10^{-5} M/s (d) 3.1×10^{-5} M/s

Matching Type

29. Match Column I with Column II and select the correct option.

Column I		Column II	
(A)	Lead storage battery	(i)	Maximum efficiency
(B)	Mercury cell	(ii)	Prevented by galvanisation
(C)	Fuel cell	(iii)	Gives steady potential
(D)	Rusting	(iv)	Pb is anode, PbO_2 is cathode

(a) (A) → (i); (B) → (iii); (C) → (ii); (D) → (iv)
(b) (A) → (ii); (B) → (iii); (C) → (iv); (D) → (i)
(c) (A) → (iv); (B) → (iii); (C) → (i); (D) → (ii)
(d) (A) → (iii); (B) → (iv); (C) → (i); (D) → (i)

30. Match the column I with column II and select the correct option.

Column I		Column II	
(A)	Rate of reaction	(i)	2 or 3
(B)	Activation energy	(ii)	mole lit^{-1} sec^{-1}
(C)	Arrhenius equation	(iii)	kcal $mole^{-1}$
(D)	Temperature coefficient	(iv)	$k = Ae^{-E_a/RT}$
(E)	Photochemical reaction	(v)	First order
(F)	Radioactive decay	(vi)	Zero order.

(a) (A) → (ii), (B) → (iii), (C) → (iv), (D) → (i), (E) → (vi), (F) → (v)
(b) (A) → (i), (B) → (iii), (C) → (iv), (D) → (ii), (E) → (vi), (F) → (v)
(c) (A) → (iii), (B) → (ii), (C) → (iv), (D) → (i), (E) → (vi), (F) → (v)
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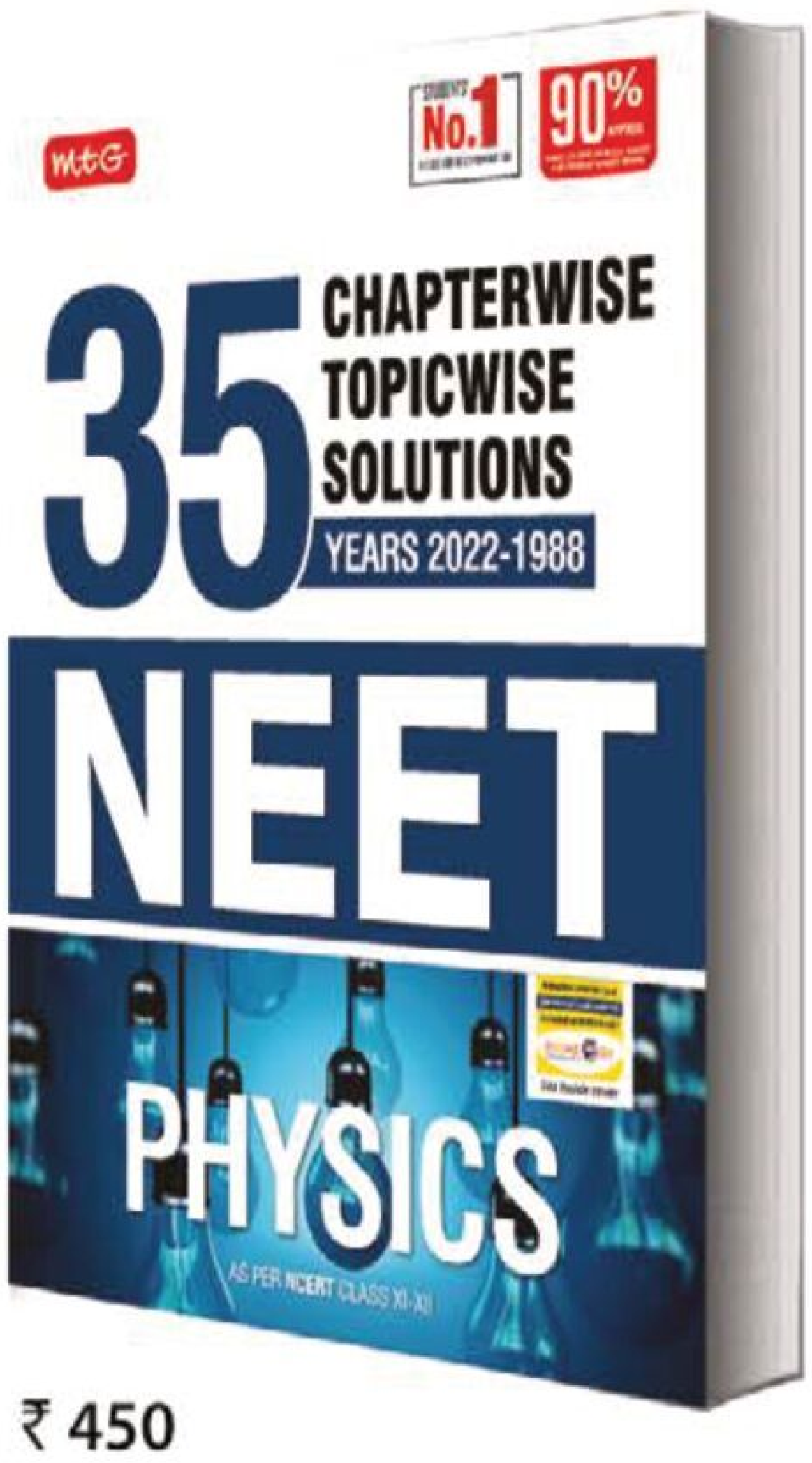
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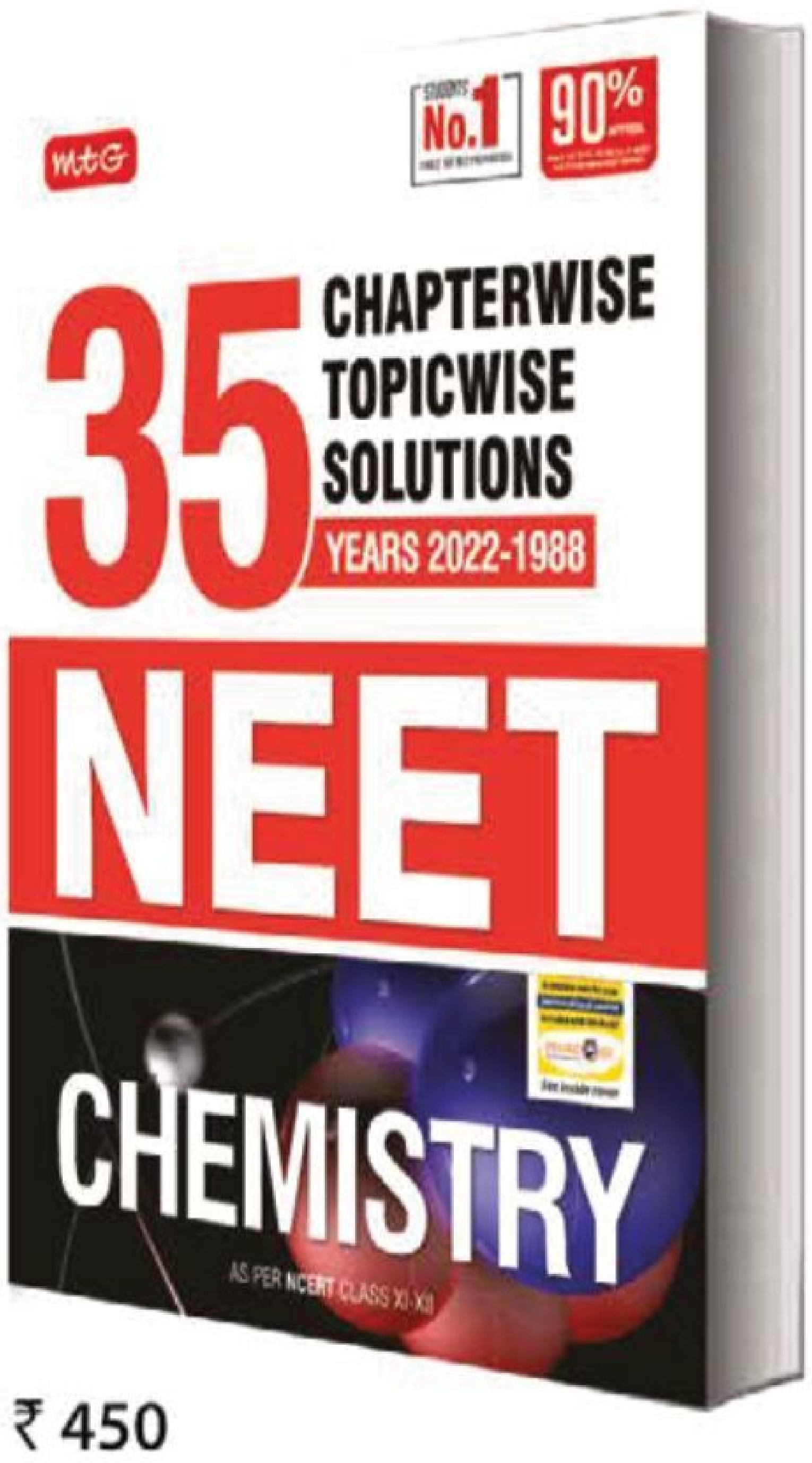
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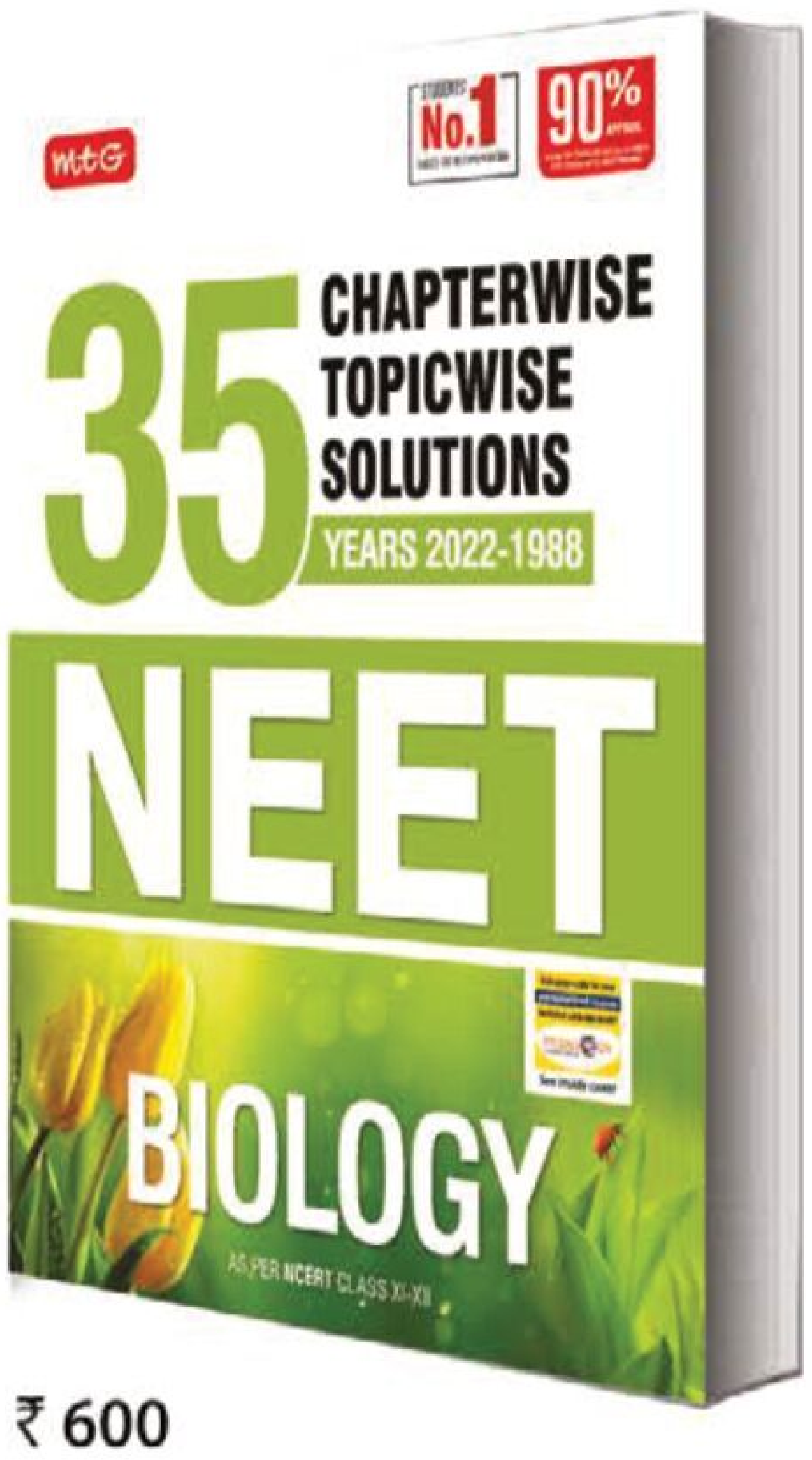
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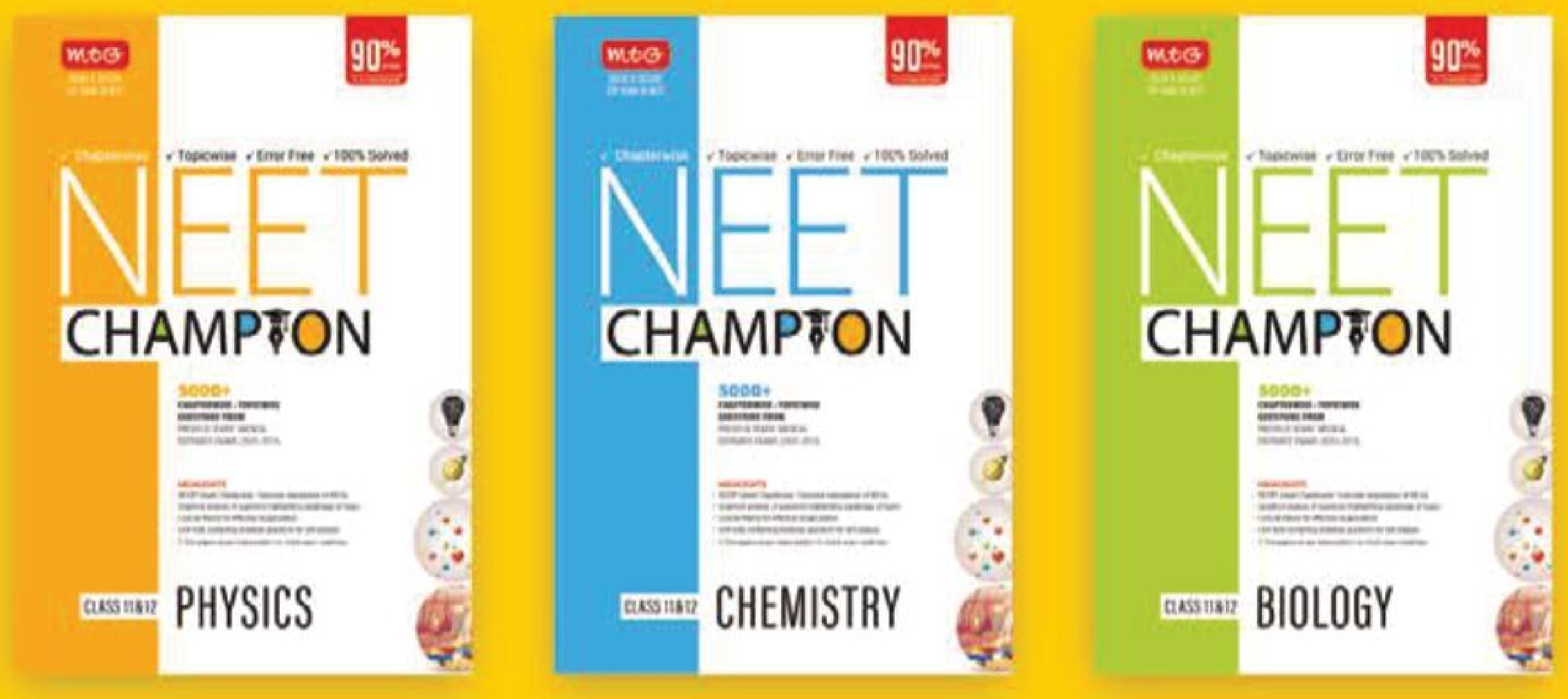

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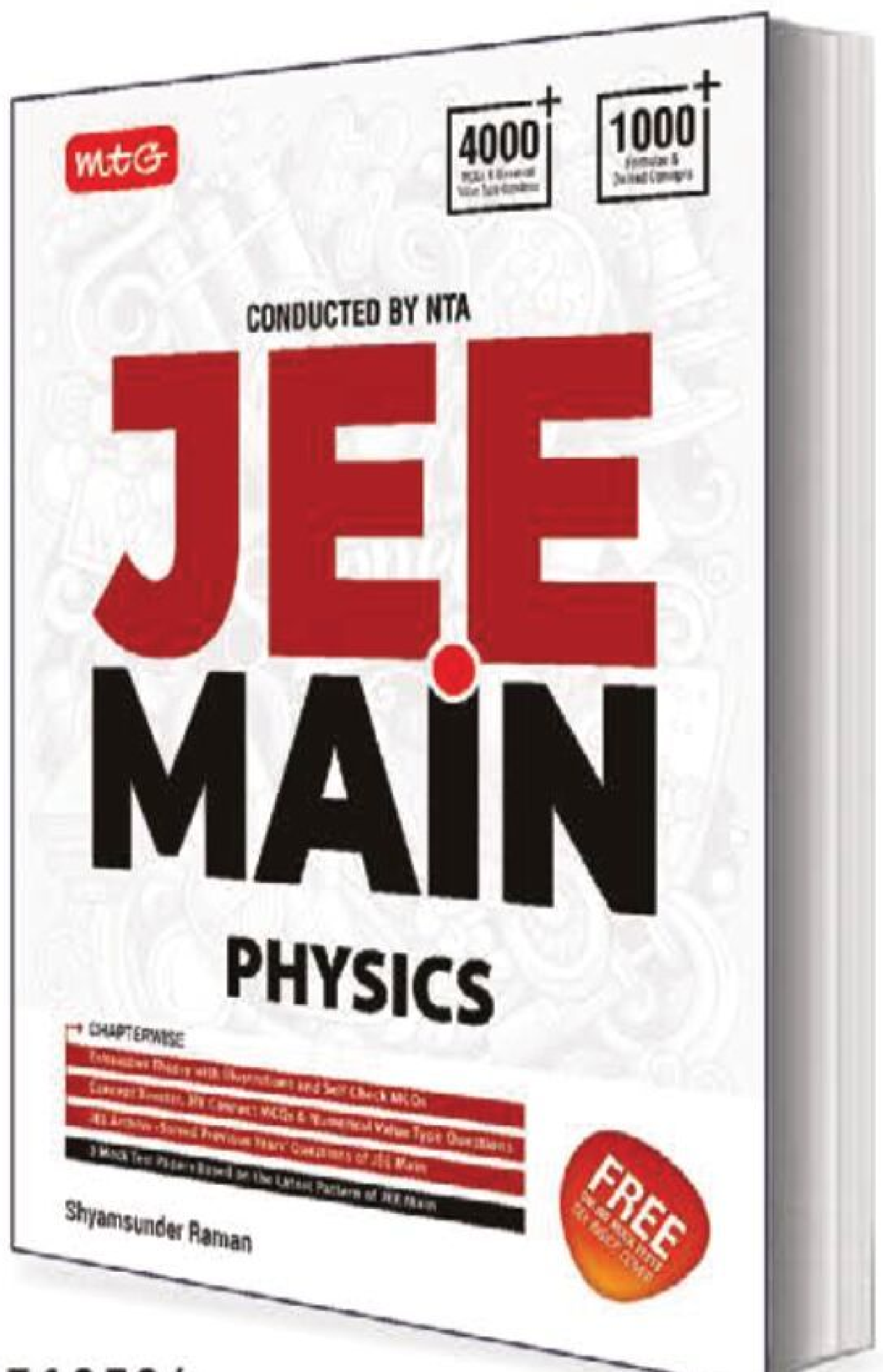
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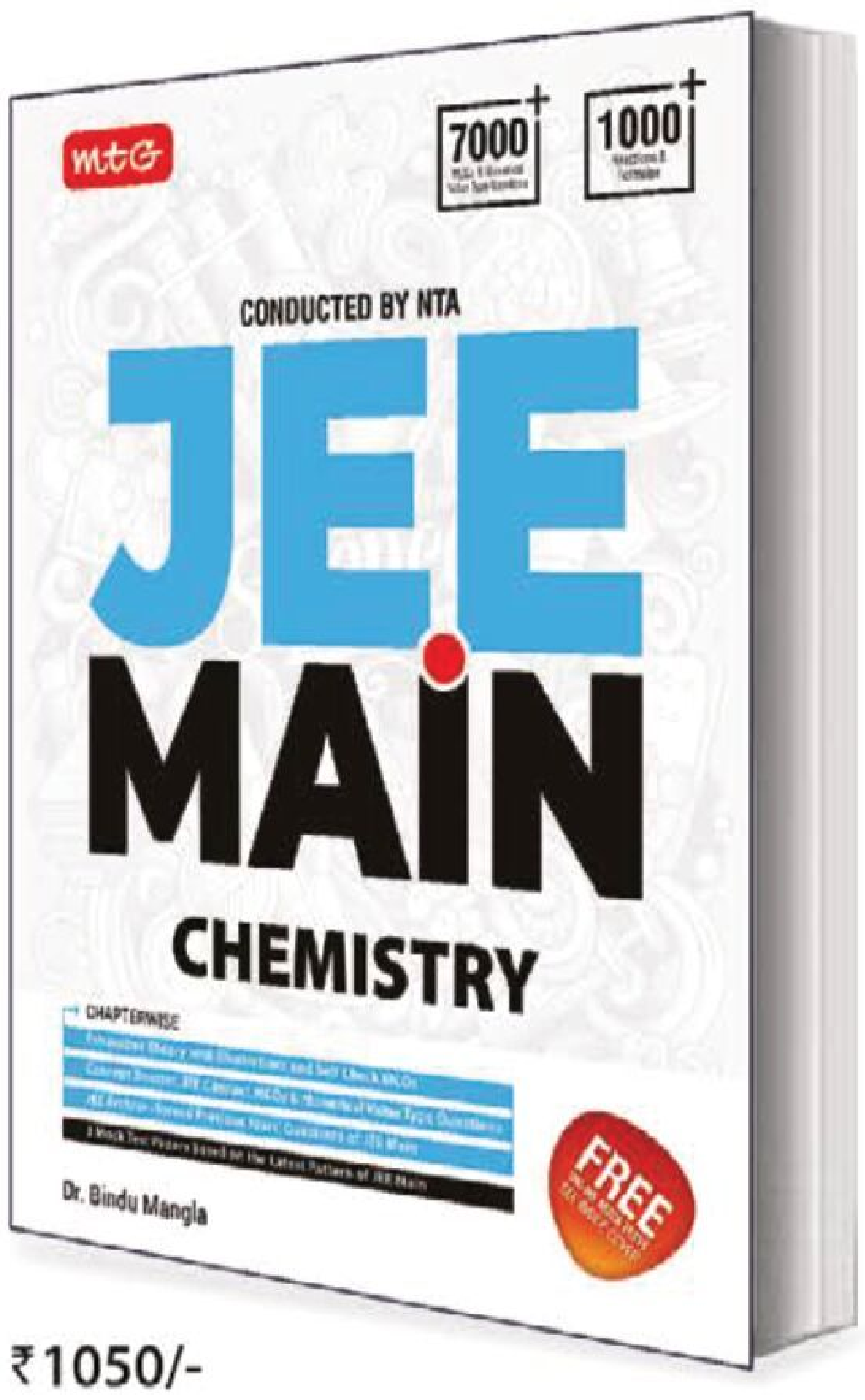
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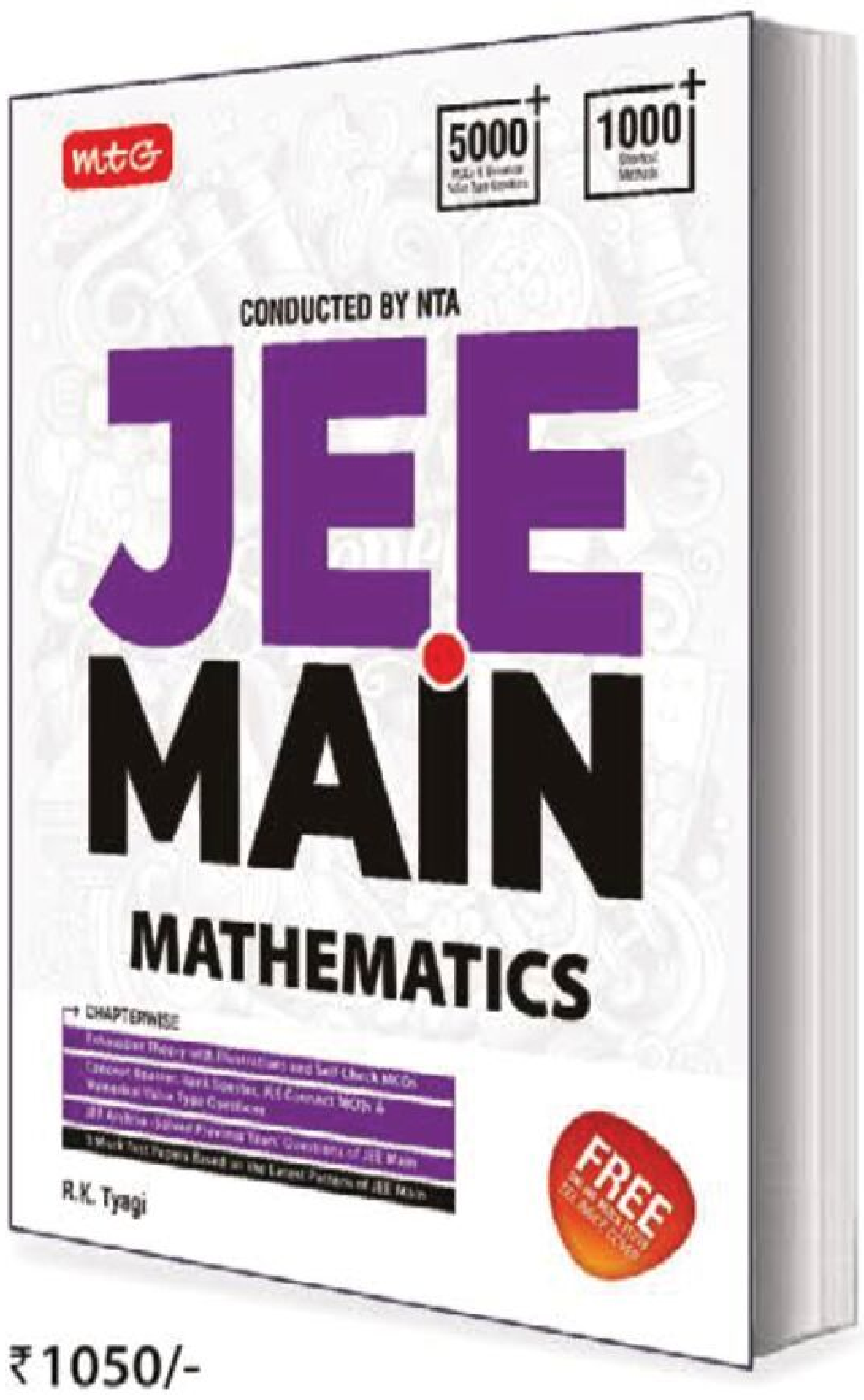
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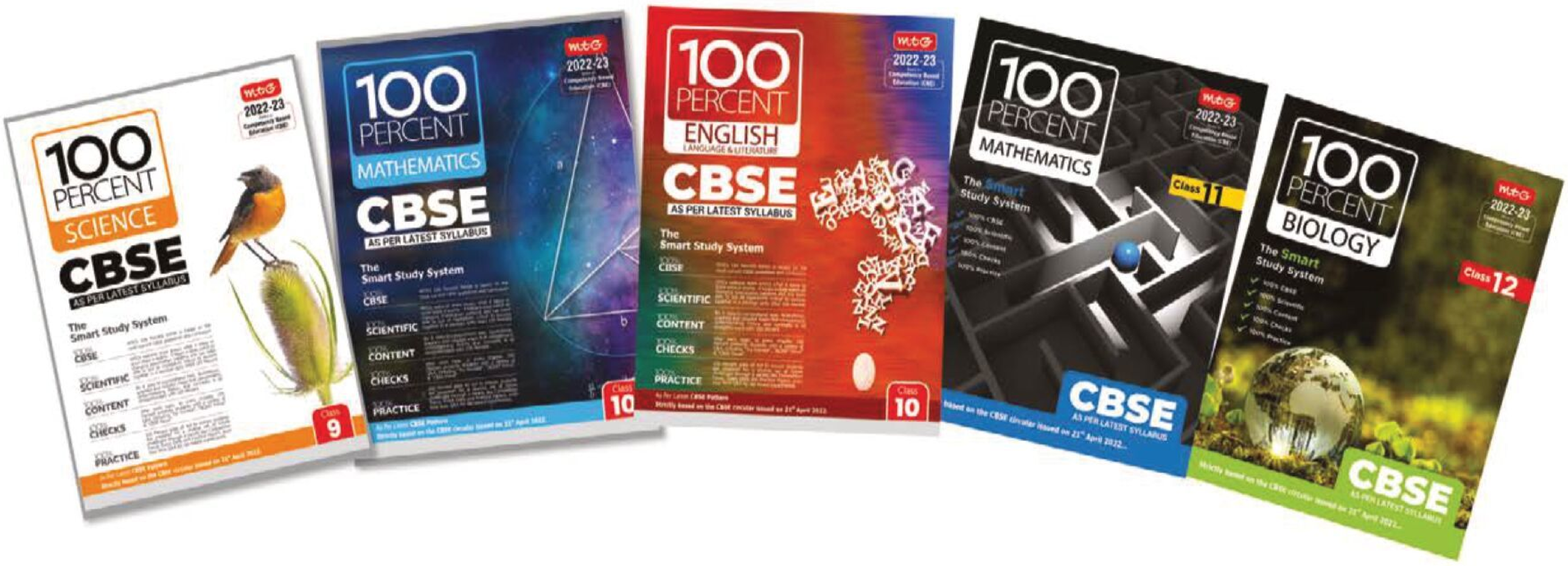

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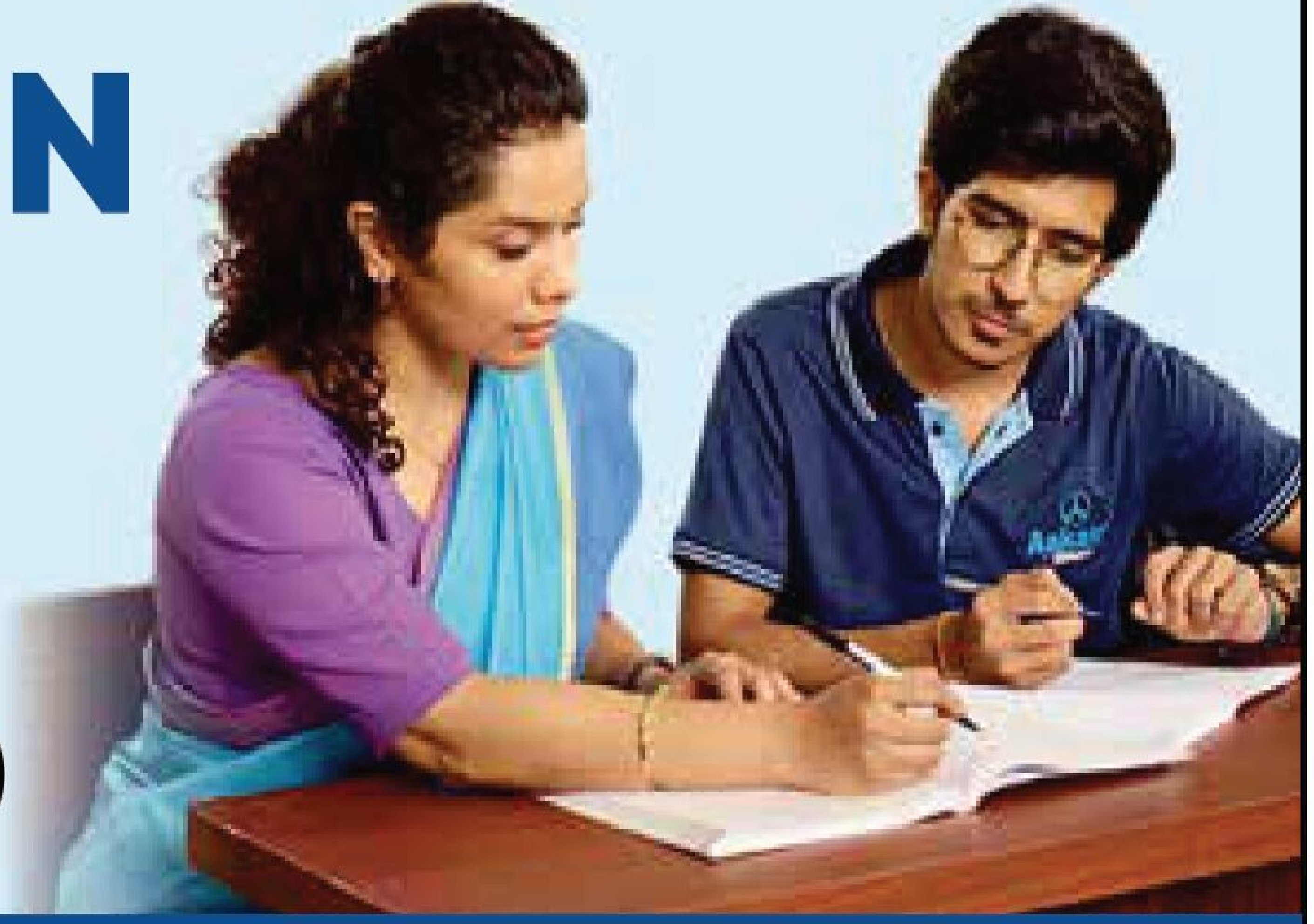

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